Aristotle and the Atomists on the Nature of “Space”

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Declaration of Authorship

I …………………… hereby declare that this thesis and the work presented in it is entirely my own. Where I have consulted the work of others, this is always clearly stated.

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Abstract

This dissertation compares the arguments of Aristotle and the Atomists with respect to the following three related questions: Whether space is infinite or not? Is there such a thing as "empty space"? Is there a limit to the division of matter? Concerning each of these questions, Aristotle and the Atomists endorsed opposite views and constructed arguments in an attempt to furnish proof for their respective views. In addition, they were aware of the other party's standpoint and often attempted to refute each other's arguments. I utilize this fact and rely on the counter-arguments of the opposing party whenever I can. While comparing the arguments, my primary objective is to decide which side argues more conclusively in this respect. Besides ascertaining its validity, I also look for reasons why a particular argument fails or holds true. Based on these, I derive some conclusions concerning certain general problems affecting the reasoning of either Aristotle or the Atomists (or both). In addition, I discuss the manner the arguments of a particular question are connected to the arguments of the remaining two questions. In other words, I reveal the connection between the three questions of my choice. Each of these questions are discussed in a separate chapter, each of which features a "mini conclusion" where I summarize the outcome of the corresponding section of my analysis. In addition, the dissertation contains an Introduction and a concluding chapter. The latter can be divided into two sections. In the first part, I summarize the conclusions of the previous chapters and decide which party argued more conclusively as a whole. The second part is devoted to the above mentioned general problems affecting the reasoning of either Aristotle or the Atomists (or both).

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Chapter I

Introduction

Numerous thinkers from the Greco-Roman world, who were affiliated with natural philosophy, held definite views about questions concerning certain general characteristics of the universe. Some of the more frequently discussed (or more fundamental) questions were the following: is space infinite or finite in extent? Are there empty parts within it or is it completely filled with matter? Is either matter, space (in its abstracted sense), or time divisible ad infinitum or not? Are there several worlds or only one? Does time (in the direction of the past) have a beginning or not? Does our world possess a beginning and end in time or is it eternal? Concerning all of the above questions, there are only two alternative ways to answer them. For instance, space is either infinite or not. There is either a beginning to time or not. Therefore, those who answered these questions inevitably assumed either of the opposite standpoints. As a result, a considerable controversy ensued where the opposing parties adduced both positive and negative arguments in their favour.

This work focuses on such a dispute between the ancient Atomists and Aristotle. Although they were in opposition concerning most of the above questions, I limit my scope to three of them which are as follows: is space infinite or finite in extent? Are there empty parts of space or is it completely filled with matter? Is there a limit to the (physical) division of matter or not? When I say Aristotle, it is obvious that I am referring to a particular individual. In contrast, the expression “ancient Atomists” denotes numerous individuals. Therefore, in their case, I must specify who is to be included in my analysis. In this respect, I apply a dual distinction in my work. On the one hand, I consider the arguments of Democritus and Leucippus whom I refer to as “early Atomists”. Although little is known about his life, Leucippus is generally accepted as the founder of Atomism, and Democritus was his pupil.[1] The adjective "early" is meant to distinguish Democritus and Leucippus, who were the first Atomists, from their later post-Aristotelian successors (especially from Epicurus and his followers). On the other hand, I consider the arguments of Epicurus and Lucretius. Here, I focus mainly on the arguments of the former who was the founder of an Atomist school commonly referred to as the Epicureans. What I mean is that whenever the same argument is present in both Epicurus and Lucretius, I analyse only Epicurus' version. However, if it facilitates understanding, or if there is a relevant argument, which is present in Lucretius but not found in Epicurus, I include Lucretius as well.[2] I will talk more about the reasons explaining my approach to Lucretius' arguments in the subsequent chapters.

After discussing whose arguments my analysis focuses on, I will explain why I chose to write about this topic. In this respect, I will discuss the underlying reasons for the following: 1, why concentrate on the arguments of the Atomists and Aristotle? 2, Why single out the above three questions? 3, Why is it useful to conduct this research in general? In order to properly understand my answer for (3,), (1,) and (2,) need to be considered first. Therefore, I will start with these, and then I will turn to (3,). One of the reasons why I choose to compare Aristotle and the Atomists originates from the fact that, in the three questions of my choice, they adopted clearly opposing viewpoints. Furthermore, in a sense, both Aristotle and the Atomists seem to relate directly to each other's arguments. What I mean is that either side demonstrates some degree of awareness of the other's opposite standpoint (and pertaining arguments), based on which the structure of their "debate" can be reconstructed.

Prior to this reconstruction, a few things relating to the life and works of these authors must be mentioned in advance. Although very little is known about Leucippus' life, it is fairly certain that he was somewhat older than Democritus who

[1] This information can usually be found in the beginning of general discussions on the life of Leucippus and Democritus. For such discussions, see the relevant chapters in: Bailey, 1928; Guthrie, 1965; Taylor, 1999.

[2] Lucretius, who was a 1st century BC Epicurean, is considered to be the chief ancient source to consult whenever an idea or argument of Epicurus requires further explanation. His extensive poem, *De Rerum Natura*, is preserved almost in its entirety and presents us with a faithful account of Epicurus' natural philosophy. For these reasons even works which are concerned primarily with Epicurus frequently consult Lucretius' poem. I will follow the same practice.

was born around 460 BC. Consequently, the early Atomists predated Aristotle by several decades, while Aristotle predated Epicurus who was born in 341 BC.[3] In the case of the early Atomists, none of their works survived. Although there are some surviving fragments preserved in latter authors, they contain little or no information about the physical theories of the early Atomists.[4] Therefore, with respect to the latter, we need to rely almost entirely on testimonia contained in secondary sources. In fact, one of the most important sources in this respect is Aristotle. Based on the available evidence, and putting aside a few cases where minor differences are indeed detectable, it is best not to make a distinction between Democritus and Leucippus when considering their physical theories.[5] This is especially true in case of the questions I am considering. After all, regarding either the size of the universe or void or the divisibility of matter, the views of Democritus and Leucippus are identical. In addition, when referring to the arguments relevant to these questions, most scholars make no distinction between them.[6] Accordingly, I make no attempt to draw a distinction between Democritus and Leucippus when analyzing these arguments. In contrast to the early Atomists, considering the relevant arguments of either Aristotle or our two Epicureans, we have a considerable amount of material in our hands. In the case of Aristotle, most of the relevant material is contained in his *Physics*, *De Caelo*, and *De Generatione et Corruptione*. In the case of the Epicureans, most of the relevant passages of Epicurus are from his *Letter to Herodotus* which is preserved in Diogenes Laertius, while Lucretius' arguments are found in his poem, *De Rerum Natura*.[7]

Returning to the reconstruction of the above mentioned debate, it all started with the early Atomists, since they were the first in time. In defense of their standpoint in

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[3] The generally accepted date for Aristotle' birth is 384 BC. For more on the life and works of the early Atomists, see: note 1. For more on the life of Epicurus, see: Bailey, 1928; Rist, 1972.

[4] Most fragments deal with ethical questions (see: Kirk, Raven, Schofield, 1983, 406).

[5] Unlike most scholars, Bailey (1928) treats Democritus and Leucippus separately, and attempts to establish a greater distinction between their physical views. However, scholars in general do not follow Bailey's approach and treat Democritus and Leucippus jointly when considering such fundamental aspects of the universe as the atoms or void (see: Cherniss, 1964; Furley, 1967, 1976; Guthrie, 1965; Kirk, Raven, Schofield, 1983; Sorabji, 1982, 1988; Taylor, 1999).

[6] For examples, refer to the works mentioned in the previous note.

[7] Obviously, I include other works in my analysis as well. Each chapter features a separate list of passages relevant to the particular question under consideration.

the controversy they furnished an argument which is often (albeit not always) also preserved by Aristotle. Even in cases when Aristotle did not relate what the Atomists said on the matter, his counter-argument reflects the fact that he was undoubtedly aware of their standpoint and attempted to refute it.[8] In other words, Aristotle frequently (albeit not always) constructed his arguments with the Atomists' reasoning in mind. In my analysis, I sometimes exploit this fact when I use Aristotle's own reasoning to refute a particular argument of the early Atomists. When we arrive at the arguments of Epicurus and Lucretius, the picture becomes a bit more complex. We encounter two alternatives in the subsequent chapters. On the one hand, we see instances when Epicurus was clearly aware of Aristotle's objections and reacted to them.[9] In contrast, there are cases when Epicurus demonstrated no such awareness, and argued in a way indicating that either he was unaware of Aristotle's objections, or he disregarded them.[10] There are examples of both alternatives in chapters II and III.

My principal reason for (1,) and (2,), which were introduced on page 6, lies in the existence of the above controversy between the Atomists and Aristotle. What I mean is that there are several features within their debate, the existence of which grounds the possibility of an exhaustive comparison (and contrast) between the opposing views. For instance, the fact that the arguments of the two sides are connected to each other in the above manner provides an ideal basis for a comparison. After all, it is easier to compare such a related group of arguments than a group where the arguments are also for or against a particular notion, but there is little or no detectable connection between the reasoning of the opposing parties. Another important feature is the fact that, in the three questions of my choice, the Atomists

[8] This does not mean that Aristotle argued exclusively against the Atomists. By and large, his usual practice when discussing a particular question is to collect several arguments from the opposition (not only those of the Atomists), then refute each in turn.

[9] Although, based on the available evidence, it is uncertain how many of Aristotle`s works Epicurus actually read (Furley, 1976, pg 84), there are Epicurean passages which attest to the fact that Epicurus was evidently familiar with several of Aristotle`s arguments and reacted to them. For more on this question, see: chapter II, pg 58-9.

[10] Epicurus frequently omits to cite his sources. Therefore, in most cases, we can only infer from the content of his reasoning that he reacts to a previous argument or furnishes an independent one.

and Aristotle adopted clearly opposing viewpoints. This fact opens up the possibility of not merely comparing, but contrasting their respective arguments as well.

With respect to (2,), I chose these three questions partly in view of the connection which exists between them. Besides the fact that all of these questions consider physical aspects of the universe, as my analysis will reveal, their respective arguments (in the case of both Aristotle and the Atomists) are also connected in various ways. For instance, Aristotle's rejection of void has an effect on several of his arguments against the infiniteness of space. What I mean is that, as we shall see, the majority of Aristotle's objections against an infinite universe (especially, those present in his *Physics*) are directed against the notion of infinite body and not against infinite space. The reason for this lies in the fact that Aristotle has already rejected the possibility of empty space elsewhere, and hence he argues against an infinite plenum (or body). A similar connection exists between void and the divisibility of matter (considered in chapters III and IV respectively). As we shall see, whether one of Epicurus' arguments for void holds true or not depends on the (physical) divisibility of matter. If, as the Atomists maintain, there is indeed a limit to the division of matter, Epicurus' argument holds. If they are wrong and matter is divisible ad infinitum, Aristotle's counter-argument holds, the latter of which is sufficiently convincing to undermine the above mentioned argument of Epicurus.[11] An additional reason for (2,) is the relative abundance of the relevant materials. What I mean is that, considering the three questions of my choice, we have several extant arguments on both sides. For instance, examining Aristotle's *Physics*, we find long sections dedicated to these questions. Looking at the opposition, several arguments for each of these questions can be attributed to the Atomists.[12] Consequently, no matter which question we consider, it is possible to analyse and contrast various arguments from both sides.

Having discussed (1,) and (2,), let us turn to the reasons underlying (3,). Before doing so, I will explain what I plan to accomplish when analysing these questions. After all, in order to appreciate why I chose to undertake this research, it is necessary to

[11] For the details, see: III.3 (especially pg 103-5).
[12] In the case of the early Atomists, this attribution is often not so evident. I will talk a bit more about this issue later.

understand my general purpose and aims of my investigation. In view of the fact that my analysis concerns a debate (between Aristotle and the Atomists), my main focus is on ascertaining its outcome. In order to accomplish this, I consider each question in a separate chapter where I attempt to determine which side "wins" (manages to prove its case) or argues more conclusively. In doing so, I assemble the relevant arguments from both sides, and ascertain their validity. I conclude that neither side achieves a complete victory. With respect to all three questions, neither Aristotle nor the Atomists manage to prove their case conclusively. That said, concerning void and the extension of space, the Atomists prove to be more successful than Aristotle.[13] Besides determining the outcome of the debate, I also look for reasons why a particular argument fails or holds true. Based on these, I derive some conclusions concerning certain general problems affecting the reasoning of either Aristotle or the Atomists (or both), which are summarized in the second half of chapter V. I refer to these as "problems" in so far as they can be regarded as reasons for failure (of the two sides in proving their respective standpoints).

Returning to question (3,), the principal reason why this research is useful lies in its uniqueness. What I mean is that, as far as I know, there is no other treatise (be it ancient or modern) which covers the same research area. Although there are works which discuss one or more of the questions listed in the beginning, they focus exclusively on a particular philosophical school (like Atomism), or have a wider scope and include more (or often all major) ancient participants in the controversy which surrounded these questions.[14] In contrast, I focus solely on one aspect of this controversy (the opposition between Aristotle and the Atomists), and look at those three questions where this opposition is the most striking, and the available material is abundant. My work can be a useful guide for those who are interested in how either the Atomists or Aristotle argued for or against the infiniteness of space or the existence of void and what kind of arguments they used. In addition, since I usually clarify the meaning of key concepts before my analysis, those who are interested in what either Aristotle or the Atomists understood under these notions can also

[13] The outcome of the debate is somewhat different with respect to each question. For my results, consult the individual conclusions situated at the end of each chapter.
[14] An example of the former: Furley, 1976. An example of the latter: Sorabji, 1988, chapter VIII.

consult my work. For instance, at the beginning of chapter III, I discuss what the concept of "void" meant for the Atomists. Scholars are in disagreement on the exact meaning of void, and the question whether the early Atomists interpreted it differently than the Epicureans is also controversial. I argue that it is more likely that the early Atomists regarded void as "empty space which can be occupied by bodies" (receptive interpretation), and not as some kind of vacuous medium which merely surrounds matter (in this "non-receptive" sense, void space cannot be occupied).[15] I also argue that, irrespective of some minor differences, the void concept of the early Atomists and that of the Epicureans were essentially identical.

After answering (1,), (2,) and (3,), I will conclude the Introduction with an outline of the subsequent chapters. I dedicate an individual chapter to each question. In each chapter, I consider the arguments of Aristotle and the Atomists separately. With respect to the latter, due to certain differences between the early Atomists and the Epicureans, I often consider their respective arguments separately as well. Despite following the same philosophical tradition and arguing for the same ideas, the relevant Epicurean arguments are somewhat different from those of Democritus and Leucippus. This means either of the following: the Epicurean argument has no close equivalent in early Atomism, or the Epicureans use a modified version of the original argument of their predecessors. [16] Furthermore, the arguments of the early Atomists must be approached in a different manner than those of either Aristotle or the Epicureans. I refer to the problem of genuineness. Since the pertaining material consists of testimonia preserved by other authors, often post-dating Democritus by several centuries, their account does not necessarily reflect the original argument of the Atomists. Even in cases when Democritus or Leucippus is mentioned by name, the original argument might have been corrupted, or the attribution itself might be

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[15] For more on the rival interpretations of void, see: chapter III.

[16] For instance, one of Epicurus' arguments for the infiniteness of space has no equivalent in early Atomism (for my description of the argument, see: chapter II, pg 27). An example when the Epicureans use a modified version of their predecessors' argument is presented in chapter IV. There, Epicurus' argument for the indivisibility of matter features both similarities and considerable differences when compared to its equivalent in Democritus: For these differences and similarities, see: chapter IV, pg 158. Notwithstanding, there are instances when the early Atomists and the Epicureans argue in a similar manner. For instance, as we shall see in chapter III (pg 103-6), both the early Atomists and Epicurus argued from the reality of motion to the existence of void. Throughout my work, I frequently refer to this as "from motion to void" argument.

false. I address the problem of genuineness within my analysis, and only include arguments which can be attributed to the early Atomists with reasonable certainty. In deference to the above differences, excluding one or two cases, I analyse the arguments of the early Atomists and those of Epicurus and Lucretius separately.

Keeping with the above outlined structure, chapters II, III and IV discuss each question in succession. Each of these chapters features their respective conclusion, in which I summarize the results of my analysis corresponding to that chapter. Lastly, in chapter V, I furnish an overall summary of my investigation. In the first half of the chapter, I provide an overall summary of the outcome of the debate between the Atomists and Aristotle. Here, I discuss which side argued more conclusively and restate the reasons why the Atomists achieved more success than Aristotle in the controversy surrounding two of the three questions: the size of the universe, and the existence of void. In the second half of the chapter, I mention some of the more common problems, which I have encountered during my analysis, and which played an instrumental role in rendering the vast majority of the discussed arguments (of both Aristotle and the Atomists) inconclusive.

Chapter II

Is Space Infinite or not?

II.1 Introduction: The difference between the “universe” (τὸ πᾶν) and the “world systems” (κόσμοι) inhabiting it

In the main part of this chapter, I will render a detailed analysis of the passages either for or against the infiniteness of space. During the course of this investigation, I will demonstrate that neither the Atomists nor Aristotle manage to prove their case. In other words, neither side provides an argument which is compelling enough to decide whether space is infinite or finite in extent. That said, as we shall see, one of the arguments of the Atomists falls close to proving the infiniteness of space, if the latter is regarded as conventional (not “curved” as modern physics maintains).[17]

Prior to the analysis of the relevant passages, I will define my subject matter: e.g. what Aristotle and the Atomists mean when saying that space is infinite or finite. In this respect, both the Atomists and Aristotle refer to the “total sum of things” (τὸ πᾶν), which must be distinguished from our “world system” (κόσμος). The latter is regarded as limited and finite both by the Atomists and Aristotle, and it is the extension of the former (the whole of space), which is the source of their dissent.[18] Here, I do not intend to provide an exhaustive analysis of the relevant corpus. Rather, my objective is to adduce some supporting evidence, clarifying the distinction between the whole universe and the world(s) inhabiting it.

With respect to early Atomism, Leucippus held that the “whole” (τὸ πᾶν) is “infinite” (ἄπειρον), and it is inhabited by an unlimited number of “worlds” (κόσμοι). In

[17] I am referring to the so called “Archytas” argument. I will discuss this argument in detail in the next section.
[18] Furley, 1987, pg 136; In fact, for Aristotle, these two words denote the same thing, since, for him, nothing physical lies beyond the Cosmos.

addition, each world is regarded as finite in extent, which can be deduced from the account of their formation:

"Out of them (from the 'elements' (στοιχεῖα)) arise the 'worlds' (κόσμοι) unlimited in number and into them they are dissolved. This is how the worlds are formed. In a given section many atoms of all manner of shapes are carried from the unlimited into the vast 'empty space' (κενόν). These collect together and form a single 'vortex' (δίνη), in which they jostle against each other and, circling round in every possible way, separate off, by like atoms joining like. And, the atoms being so numerous that they can no longer revolve in equilibrium, the light ones pass into the empty space outside, as if they were being winnowed; the remainder keep together and, becoming entangled, go on their circuit together, and form a primary 'spherical system' (σύστημα σφαιροειδές)."[19]

Putting aside the various stages of the formation of worlds, here, I am only concerned with the relation between the "universe" (τὸ πᾶν) and the numerous "worlds" (κόσμοι) inhabiting it. In a large empty section of the universe, atoms of all sizes and shapes congregate and form a single vortex (δίνη), which in turn develops into a "spherical world system" (σύστημα σφαιροειδές). In addition, we are told how this new-born Cosmos acquires a distinct outer "layer" or "shell" (ὑμήν), which separates it from the outer universe.[20] There are several statements in this account, which attest the fact that the universe and the world are distinct from each other and the latter is finite in extent. Let us enumerate these statements: 1, there is an unlimited number of worlds; 2, each world is formed in an empty section of the universe; 3, each Cosmos possesses a specific geometrical shape (in this case, a sphere), with an "outer layer" (ὑμήν) serving as its defining boundary. Since a world only occupies a part of the universe, from (1,) and (2,) it is evident that the whole is larger than any of the worlds. This does not necessarily rule out the possibility of an infinitely extended Cosmos, since even a portion of a thing can be indefinitely large. For instance, although even numbers constitute only half of whole numbers, there are still infinitely many of them. Statement (3,) on the other hand, might furnish the necessary proof we are seeking. It says that the spherical "world system" has an "outer layer" (ὑμήν), which serves as a kind of boundary, delineating it and defining its dimensions. Having a surface and an edge are both regarded as representatives of

[19] Diogenes Laertius, ix.31.
[20] Diogenes Laertius, ix.32.

finite objects. Epicurus even uses the notion of "having a boundary" (ἄκρον) as a requisite of finiteness.[21] Therefore, by virtue of having an outer shell, each Cosmos ought to be limited.

Just like Leucippus, Democritus also believed in the infinite multitude of worlds, and used the "vortex model" to explain their creation.[22] Based on the similarities in their cosmogonies, it is safe to assume that Democritus` Cosmoi are limited as well. When explaining the creation of "world systems", Epicurus deviates from the traditional Atomist account.[23] Nonetheless, he still retains the idea that a world is created within a "circumscribed portion" (περιοχή) of the universe (hence, smaller than it). In addition, each Cosmos possesses a "boundary" (πέρᾰς), which limits and delineates it from its surroundings. As we have seen above, being bounded is an attribute of finite things. Therefore, it follows that Epicurean worlds are finite as well.[24] In conclusion, Atomist cosmogony clearly distinguishes between the universe (the whole) and the numberless world systems inhabiting it, and regards the former as infinite and the latter as finite in extent.

Now, let us turn to Aristotle, and decide whether his single Cosmos encompasses all things or not. Here, I will present Aristotle's world system only briefly with the primary objective of demonstrating that his Cosmos includes all things material, and there is nothing (not even empty space) outside of it. The most exhaustive account concerning the composition of our world is presented in *De Caelo*, where Aristotle

[21] Diogenes Laertius, x.41.

[22] Diogenes Laertius, ix.44-5; Democritus further elaborated the cosmogony of his master, and slightly modified it at certain places. For instance, he added that the worlds differ in size and composition, and lie unequal distances from one another (Hippolytus, Refutations I.13.2=DK 68A40). However, it would be too lengthy to discuss these differences here. For more on this topic, see: Furley, 1987, pg 140-151; Bailey, 1928, pg 138-155.

[23] Rather than relying solely on the actions of the vortex as his predecessors did, Epicurus stresses the importance of having the appropriate atoms or "seeds" (ἐπιτήδειον σπέρμα) congregating in a more or less void place, and explains the creation of the worlds as a result of their interplay (Diogenes Laertius, x.89). It would be too long to expound the details of this process. Since Epicurus' account is rather succinct, it is advisable to read it jointly with the much more elaborate description found in Lucretius (*De Rerum Natura*, 4.416-508). For more on the ways in which Epicurus deviates from the earlier Atomists, see: Bailey, 1928, pg 359-368.

[24] Diogenes Laertius, x.88.

enumerates the various characteristics of the Cosmos and, in most cases, furnishes reasons explaining these characteristics.[25]

In turn, let us look at the arguments which attest that the whole Aristotelian universe is comprised of a single finite Cosmos. Firstly, Aristotle asserts that there can be only one world.[26] In order to appreciate this statement, we must look at what Aristotle has to say about the motion of material bodies and his "elemental theory". With respect to the former, Aristotle divides all forms of motion into two contrary movements of natural and forced.[27] Concerning natural motion, the *Physics* says that each natural object possesses an inner principle and cause for movement (its natural motion), which is present in it "by itself" (καθ᾽ αύτο) and not "coincidentally" (καθὰ τὸ συμβεβηκός).[28] In other words, without being hampered, a thing naturally moves in a certain way, and towards a certain place.

Concerning the elements, with certain modifications, Aristotle adopted the theory of Empedocles, which states that all material objects are comprised of four basic elements of "fire", "earth", "air" and "water".[29] These elements serve as the basic

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[25] I have modified the order, in which these properties are presented in *De Caelo*, in such a way as to suit my subject matter better. Besides *De Caelo*, in the current part of my discussion, I will also refer to book VIII of Aristotle's *Physics*, which contains some relevant information, especially in respect of the so called "unmoved mover".

[26] Aristotle, *De Caelo*, I.8, 276b20.

[27] Aristotle, *De Caelo*, I.2, 269a33-5; III.2, 300a20-25; Strictly speaking, not all forms of motion can be characterized as either natural or unnatural. I am referring to the circular movement of the outer "shell" of fire, mentioned by Aristotle in his *Meterologica* (340b32-a4). Here, it is described that, by virtue of contact, the outermost layers of fire are carried round by the incessantly rotating heavens in a way which is neither natural nor unnatural to it. Whether the revolution of this so called "fire-sphere" fits into the dual categorization of all motions into natural or unnatural has been debated since ancient times, and it would not be relevant to go deeper into this controversial issue. Nonetheless, such exceptions are few and far between, and virtually all actual motions can be categorized as either natural or unnatural. For more on the subject, see: Leggatt, 1995, pg 179; Hankinson, 2009, pg 101 and 106-7.

[28] Aristotle, *Physics*, 192b20; It would be too lengthy to enunciate the various meanings of the term "καθ᾽ αύτο". Here, let it suffice that if a principle is "in itself" an attribute of an object, it means that this principle is part of the "essence" or "definition" (οὐσία) of the thing. Whereas, if it belongs to the object only "coincidentally", the attribute isn't present in its definition. For more on the various meanings of "καθ᾽ αύτο" see: Aristotle's *Metaphysics* (1022a14-35) and *Posterior Analytics* (I.4) (especially Barnes' notes (1975, pg 112-5)).

[29] Recounting all the modifications to Empedocles' theory, which Aristotle implemented, is not relevant to my work. One of the more significant among these changes is the introduction of a fifth element (the so called αἰθήρ) to serve as a constituent of the heavens, the outermost section of the Cosmos (*De Caelo*, 1.2-3). I will deal with this element in a bit more detail later on. For more on this subject, see: Solmsen, 1960, pg 287-303. On a detailed evaluation of some of the arguments attesting the existence of a fifth element, see: Hankinson, 2009.

building blocks of all material objects. Based on the number of these elements present in their constitution, Aristotle divides all bodies into "simple" (ἁπλῆ) bodies, comprised of only one type of element, and "compound" (μικτός) ones which have a mixture of elements.[30] Furthermore, as is corroborated in the *Physics* (192b20), for each body, there must be a corresponding natural motion which is inherently present in it.

"But since every natural body has its proper movement, and movements are either simple or mixed, 'mixed' (μικτός) in mixed bodies and 'simple' (ἁπλῆ) in simple, there must obviously be simple bodies; for there are simple movements"[31]

"Bodies are either simple or compounded…Necessarily, then, movements are also will be either simple or in some sort compound – simple in the case of the simple bodies, compound in that of the composite"[32]

Here, Aristotle further develops his theory of natural motion by dint of applying the same distinction of simple and compound both to bodies and to movements.[33] Then, based on this division, he derives two statements: 1, pertaining to their corresponding natural motions, simple bodies (the four elements) have simple motions, while the movement of compound ones are compound; 2, since there are simple motions, there must be simple bodies as well.

Solmsen seems to accept this latter statement without reservations, and attributes considerable significance to it. He argues that *De Caelo* utilizes this latter deduction both to provide proof for the existence of simple bodies, and to ascertain their number.[34] For my part, I am less convinced by these conclusions, and there are more potent arguments put forth by Aristotle to support the existence of his elements.[35]

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[30] Aristotle, *De Caelo*, III.3, 268b26; In the passage, the adjectives, σύνθετος and μικτός are used interchangeably to denote compound bodies. Accordingly, I will regard them as synonyms.
[31] Aristotle, *De Caelo*, III.3, 302b5-8.
[32] Aristotle, *De Caelo*, I.2, 268b26-269a1.
[33] Concerning in what sense movements are simple, *De Caelo* (I.2, 268b20) states that all locomotion can be described through the combination of the two basic movements of "straight" (εὐθεῖα) and "circular" (κύκλος).
[34] Solmsen, 1960, pg 254.
[35] I am referring to the theory of "weight" and "lightness" and its intimate connexion to the 4 elements (especially that of fire and earth) discussed in book III.3-4 of *De Caelo*. I will return to this topic a bit later.

The first problem comes from the fact that *De Caelo's* statement that "mixed or compound bodies have compound motions, whereas simple ones possess simple motions" (1,) is left unexplained, and I see no reason to regard (1,) as self-evident. Looking at (2,), the fact that there are simple motions does not necessarily entail the existence of simple bodies unless we presuppose that "only simple bodies can perform simple motions". However, this is hardly the case, since all bodies (not just the four elements) move either up or down in straight lines by virtue of possessing either weight or lightness.[36] Therefore, this kind of simple movement is in no ways unique to the elements. All in all, neither (1,) nor (2,) hold, so the above argument cannot prove the existence of simple bodies.

With respect to the number of the simple bodies, as Solmsen points out, the opposed linear motions of towards and away from the centre can only explain two of the four elements (fire and earth), and the supplementary argument, which intends to substantiate the existence of the remaining two elements, is rather inconclusive.[37] Moreover, Hankinson argues that, although each simple body possesses a unique simple motion (earth moves rectilinearly towards the centre, fire tends towards the circumference,…), it is not the case that *"every determinable simple trajectory must have some simple body whose nature it is to move along it."*[38] If this is correct, the number of elements cannot be deduced reliably from the number of simple motions, since there might exist some simple trajectory lacking a corresponding elemental motion. In fact, as the following account reveals, such a potential trajectory is indeed conceivable. However, first, let us find out exactly what "simplicity" means with respect to locomotion.

Although no exhaustive definition of simple motion is provided in *De Caelo*, elsewhere Aristotle argues that movement derives its characteristics from its corresponding trajectory: *"…change 'follows' (ἀκολουθεῖ) the 'magnitude' (μέγεθος)*

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[36] According to Aristotle, the natural movement of a compound body is prescribed by the element, which preponderates in its composition (*De Caelo*, I.2, 269a1-5). For more on this question, see: Leggatt, 1995, pg 178.
[37] Aristotle, *De Caelo*, IV.4, 312a6-12 and IV.5, 312a30; Aristotle advances other arguments to distinguish the two intermediate elements from earth and fire, but their exposition is not relevant to my topic. For more on this question, see: Gill, 2009, pg 141-6; Solmsen, 1960, pg 284-85.
[38] Hankinson, 2009, pg 84.

: it is because the magnitude is continuous that the change is too."[39] Adapting this definition to our needs, locomotion, being a kind of change, also depends on the "route" (μέγεθος) it traverses. Here, "ἀκολουθεῖ" should be understood in a causal sense, meaning "follow as a consequence", while "μέγεθος" refers to an arbitrary extension, such as a line or a surface (not just three-dimensional figures).[40] Since "μέγεθος" can denote lines, in the following account concerning the simplicity of motion, I will render "μέγεθος" as "route" or "trajectory". Consequently, movement along a simple trajectory, will itself be simple as well. What remains is to ascertain the simplicity of a trajectory. As written in the *Physics*, a "uniform" (ὁμαλός) route is such that any given section of it fits onto another perfectly (provided that both are similar in length). Since, in the case of lines, uniformity and simplicity are congruent, the above holds true of simple trajectories as well.[41] In conclusion, simple movements are those which follow uniform routes.

However, based on these requirements which render a motion "simple" (ἁπλῆ), another potential candidate for simple motion can be conceived which is not mentioned by Aristotle: the motion around a "cylindrical helix" (a spiral with a constant inclination), which is also uniform in so far as all its parts are congruent. As part of his attack on Aristotle's argument for αἰθήρ, Xenarchus of Seleucia points out that, in spite of being potentially uniform, the spiral lacks its corresponding natural motion.[42] In other words, none of the elements have their movement around a spiral. Therefore, Aristotle's argument (*De Caelo*, 268b20-269a7), which proceeds from simple magnitudes (in this case, the spiral is an example of a simple line) to simple motions, and from simple motions to a corresponding simple body, is rendered unjustified by the fact that there exists a simple magnitude (the spiral) without a corresponding element. In other words, simple trajectories cannot be regarded as sufficient explanations of simple motions. That said, it is probable that Aristotle did

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[39] Aristotle, *Physics*, 219a11-3 (Hussey's (1983) translation).

[40] Examples for the usage of "μέγεθος" to denote lines or trajectories (of motions): With respect to the *Physics*, see: 219a10-3 with Hussey's notes (pg 142-3); In *De Caelo*: 268b19-20 with Leggatt's notes (pg 176).

[41] Leggatt, 1995, pg 176-7; For the definition of uniform magnitudes, see: Aristotle, Physics, 228b22-5.

[42] Simplicius, *On the Heavens*, 13,22-8.

not ascribe such a direct explanatory role to simple magnitudes. Rather, he might have held that all simple motions follow uniform trajectories, but not every conceivable simple trajectory can be paired with a simple movement.[43]

Despite these considerations, the controversial status of the spiral still baffled ancient expositors of Aristotle, who attempted to redress the problem by looking for additional requisites for simplicity besides the "congruity of parts" mentioned above, which would exclude the helix from the company of simple magnitudes.[44] However, the whole controversy loses its significance if we postulate that Aristotle was unaware of the simplicity of the spiral.[45] The fact that this might well be the case is further affirmed by the following: firstly, *De Caelo* explicitly states that the sole two simple magnitudes are the circle and the line. Secondly, the uniformity of the helix was first proved by Apollonius of Perga a century after Aristotle. Thirdly, the list of examples for non-uniform magnitudes includes the "regular spiral" (ἕλιξ).[46] All in all, it is unlikely that Aristotle regarded the spiral as a simple trajectory. Consequently, in my interpretation, *De Caelo* does argue from simple trajectories to simple motions,[47] and from the latter to simple bodies. After all, his argument for the existence of a "fifth" element (αἰθήρ) evidently hinges upon the following supposition: if there is a simple motion of moving in a circle, there must be some peculiar element, with an inherent nature to move in this way.[48] Although it is not stated explicitly, the phrasing of the conclusion that "*there* ***must necessarily be*** *some simple body which revolves naturally*" (ἀναγκαῖον εἶναί τι σῶμα ἁπλοῦν ὃ πέφυκε φέρεσθαι τὴν κύκλῳ κίνησιν) implies that, for Aristotle, the existence of a particular simple motion necessarily entails that of a corresponding simple body.[49]

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[43] Simplicius, *On the Heavens*, 13, 28-14, 3.
[44] An enumeration of these additional requirements, and a more detailed analysis of the matter see: Hankinson, 2003, pg 22-6.
[45] Hankinson, 2003, pg 24.
[46] Aristotle, *De Caelo*, I.2, 268b20; Aristotle, *Physics*, 228b23-4.
[47] Excluding the helix, only the circle and the line remain as a simple magnitude, and both have a corresponding simple motion.
[48] Aristotle, *De Caelo*, I.2, 269a2-6.
[49] There are further implicit assumptions required to make the argument in 269a2-9 work; however, a detailed analysis of it is not productive for my work. For the full list, see: Leggatt, 1995, pg 178.

In conclusion, there are certain problems with respect to *De Caelo's* arguments aiming to substantiate the existence of the elements, especially that of αἰθήρ. As we have seen, the main body of the criticism concerns the validity of the deduction of simple bodies from simple motions (for Aristotle's pertaining argument, see: page 17). In addition, the number of the elements also cannot be explained solely by dint of the number of simple motions, since the opposed linear motions of towards and away from the centre can only explain two of the four elements. Finally, there is a controversy surrounding the exact number and definition of simple magnitudes. Since the latter underlies the definition of simple motion, these problems have a detrimental effect on the reliability and applicability of the tenets of simple motions. However, since these problems are not directly relevant to my topic, I will not dwell upon them further.

So, for the present, I will put aside the implications of the above refutations, and accept Aristotle's elemental theory owing to the fact that it functions as a premise in the argument directed against the plurality of worlds, which is the one I am currently concerned with. After all, no reasoning can be appreciated if its premises are rejected from the start. Therefore, let us proceed directly to this question, and construe the relevant passages.[50]

As we have already stated, for each natural object (including the elements), there is a pertaining natural motion.[51] This is further corroborated by the observed fact that all material things have "weight", and, unless impeded, they either rise above or sink below the others (this is their natural movement), depending on whether they are heavier or lighter that their environment. Aristotle goes further and states that among all bodies, there must be one which is absolutely heavy, and another which is absolutely light. The former he defines as "that which sinks to the bottom of all things", whereas the latter as "that which rises to the surface of all things".[52] The absolutely (ἁπλῶς) heavy is identified with the element of earth, whereas fire is

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[50] The chief argument is presented in book I.8 of *De Caelo*, but I will use other passages to "supplement" it.
[51] See: pg 16-7.
[52] "βαρύ μέν ἁπλῶς τὸ πᾶσιν ὑφιστάμενον, κοῦφον δὲ τὸ πᾶσιν ἐπιπολάζον" (*De Caelo*, IV.4, 311a16);

absolutely light. The former always moves downwards towards the centre of the universe (this is analogous to "sinking below all bodies"), while the latter has its movement in the opposite direction, towards the "extremity" or "circumference" (ἔσχατον).[53] Therefore, these motions are "goal directed", and terminate in the centre or along the circumference respectively.

Having laid down what it means to be heavy and light and ascertained their respective movements of towards and away from a specific point (the centre of the universe), let us proceed to Aristotle's chief argument against the plurality of worlds. Aristotle proceeds indirectly, demonstrating the absurd consequences, resulting from the possibility of having several coexistent world systems:

"Further, these worlds, being similar in nature to ours, must all be composed of the same bodies as it."[54]

In other words, the elements are the same no matter which Cosmos they are in. Furthermore, since the natural movements of those objects which are similar in "form" are identical, this motion must be directed towards the same destination, which is numerically one.[55] It follows that all the earth, no matter in which Cosmos it is, will have its motion towards a particular centre, and all the fire to the corresponding particular circumference:

"Clearly, then, one of the bodies will move naturally away from the centre and another towards the centre, since fire must be identical with fire, earth with earth, and so on, as the fragments of each are identical in this world"[56]

In other words, the natural motion of the elements excludes the possibility of having more than one world centre (and extremities). This entails that the elements in their respective worlds would behave absurdly:

[53] Aristotle, *De Caelo*, IV.4, 311b15-25; The pairs of "τὸ πᾶσιν ὑφιστάμενον" (sinking below all others) and "τὸ πᾶσιν ἐπιπολάζον" (rising above all others), and "ἀεὶ ἄνω φέρεσθαι" (always moving up) and "ἀεὶ κάτω φέρεσθαι" (always moving down) are two different ways of referring to the opposed motions of earth and fire.
[54] Aristotle, *De Caelo*, I.8, 276a32.
[55] Aristotle, *De Caelo*, I.8, 276b30-2.
[56] *ibid*., 276b4-6.

"…earth must, in its own world, move upwards, and fire to the centre; in the same way the earth of our world must move naturally away from the centre when it moves towards the centre of another universe."[57]

Aristotle's examples are a bit muddled, but their meaning is clear: it's impossible that earth moves downwards in each Cosmos, since the above considerations showed that there is only one centre towards which it can move. So, unless a particular world centre (let's call this world "X") coincides with the "universal" centre, to which all the earth moves, earth (and all heavy things) will naturally move not downwards in X, but in another direction. Since this is an impossibility, there can only be one Cosmos, whose centre must coincide with that of the whole universe. Here, I am not concerned with refuting this conclusion. After all, unless we reject Aristotle's theory of natural motion, it is hard to find fault with the argument.[58] Therefore, I conclude that, based on the characteristics of the Aristotelian system, there can only be a single Cosmos.

To the question whether there is anything physical besides this single Cosmos, Aristotle's answer is negative. Let us investigate his reasons. Firstly, if there is anything outside of the "heavens" (οὐρανᾰνός), it must be either body or empty space. The former possibility is firmly rejected by Aristotle: *"…there neither is, nor can come into being, any body outside the heaven."*[59] Here, it is sufficient to prove the impossibility of extra-cosmic "simple" (ἁπλόος) bodies, since all "compound" (σύνθετος) objects are comprised of these.

As we have seen, an element's natural motion is directed towards a particular place where the element is naturally at rest. This is its natural place, whereas to be elsewhere is unnatural to it.[60] Aristotle relies on this latter distinction of natural and unnatural places to prove that there can be no body outside of the Cosmos. The structure of his argument (*De Caelo*, 278b25-279a2) is as follows: if there is a simple

[57] *ibid*., 276b15-8.
[58] Solmsen also seems to fully agree with it (1960, pg 257-8).
[59] *De Caelo*, I.9, 278b24.
[60] In the argument, Aristotle distinguishes the place where the element rests "naturally" (κατὰ φύσιν) from all the other places, where it stays "unnaturally" (παρὰ φύσιν). A constant effect of an external force is required to keep the element away from its natural place.

body outside the heavens, it is there either "naturally" (κατὰ φύσιν) or "unnaturally" (παρὰ φύσιν). The former case is not possible, due to the fact that all elements have their natural places within the Cosmos.[61] As a consequence, if there is something outside, it must be there against its own nature. However, this latter cannot be the case either, since "a place which is unnatural to one body must be natural to another", and the argument has already demonstrated that there is no body in existence whose natural place is outside of the Cosmos. Therefore, Aristotle concludes that all bodies, both simple and compound, must be within the Cosmos.[62] Furthermore, as Aristotle points out, it is not only the case that there is no extra-cosmic body now, but there cannot be one in the future either, since the above mentioned arguments will also apply to any body which might enter into extra-cosmic space in the future.[63]

With respect to the other possibility of having empty space outside of the Cosmos, Aristotle argues against it in several places in his works. Numerous arguments are advanced to disprove the existence of void (situated either within or outside of the Aristotelian Cosmos), which I will consider in the next chapter. However, *De Caelo* (279a12-8) adduces a specific cause, which I intend to investigate here in separation from the arguments found elsewhere. The argument proceeds in the following manner: 1, "void" (κενὸν) is something which is empty of body, but can potentially receive bodies; 2, there neither is nor can be any objects outside of the heavens (this Aristotle has already concluded at 278b25-79a8); 3, finally, we can supplement the argument with an additional thesis that, for Aristotle, there is no such thing as a possibility or potentiality, which cannot be realized.[64] Statement (2,) implies that there never will be a time, when a material object is found beyond the heavens. Therefore, extra-cosmic void cannot actualize its potentiality of accommodating

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[61] According to Aristotle's Cosmology, the Cosmos is spherical (*De Caelo*, II.4, 286b10), and comprised of concentric layers of the five elements. Concerning the natural places of these simple bodies, proceeding from the centre outwards, first comes the element of earth, then water, air, fire, and lastly αἰθήρ, which occupies the outermost circumference of the Cosmos (*De Caelo*: I.8, 277b15-25; IV.4, 312a5-13).

[62] Aristotle, *De Caelo*, I.9, 279a6-10.

[63] *ibid*., 279a2-8.

[64] For more on this question, see: Hintikka, 1966.

bodies. Since possibilities, which cannot be realized, are rejected (3,), and void is something whose existence hinges on this potentiality (2,), there can be no extra-cosmic void either.[65]

By and large, it is hard to find fault with these arguments. They are reasonably perspicuous, and the conclusion follows from the premises. My only objection is that the statement that "a place which is unnatural to one body must be natural to another" (*De Caelo*, 278b34) is taken for granted by Aristotle, and is left unexplained. In fact, this assertion already appears in book I.2 of the *De Caelo*, where Aristotle attempts to corroborate it with an example: the upward motion is unnatural to earth and natural to fire, and conversely, the downward movement is unnatural to fire and natural to earth.[66] However, this can hardly substantiate the above statement, and the Greek found in these lines further reflects this fact. The presence of οἷον (such as) in the subordinate clause οἷον ἡ ἄνω καὶ κάτω πέπονθεν implies that Aristotle provides an example and not a reason or proof for the notion that "all unnatural motions (and places) must have a corresponding natural one".

On the contrary, this assertion functions here as an already accepted axiom further corroborating the existence of a fifth element which naturally revolves in a circle: "*It necessarily follows that circular movement, being unnatural to these bodies (earth and fire), is the natural movement of some other.*"[67] In this instance, Simplicius is of little help as well. In his commentary, he simply reiterates the statement, and adduces the same example of the opposed movements of earth and fire.[68]

As far as I am concerned, the notion that "a place which is unnatural to one body must be natural to another" (let "A" denote such a notion) requires an explanation. Since Aristotle gives none, I shall attempt to devise some in his stead. Since Aristotle

[65] In fact, besides void (or place), the argument also denies the existence of time outside of the heavens on the same grounds. However, due to my subject matter, I only consider the argument with reference to void.
[66] *ibid.*, 269a32-b1.
[67] *ibid.*, 269b1-2.
[68] Simplicius, *On the heavens*, 243, 30-244, 5.

rejects void (empty space), his universe is completely filled with bodies. In other words, all parts of space are either natural or unnatural to some objects. In order to validate the above assertion, we must presuppose that "all parts of space are natural to one of the bodies" (P). This way, no matter where an object is being kept against its nature, that place would be natural to some other plenum. Consequently, (A) holds true only by way of (P). Admittedly, supposing that "all bodies have a distinct natural place (and there is no void)" leads to the same conclusion. Although this is certainly an Aristotelian notion, it is not expressed here. So, the statement that "all bodies have a distinct natural place (and there is no void)" cannot be regarded as part of his original argument found in the *De Caelo* (I.9). Putting aside this minor objection, I tend to agree with this latter argument. As long as the tenet of "natural motion (and places)" is recognized, there can be nothing outside of the Cosmos. Of course, neither I nor the Atomists are compelled to accept any of Aristotle's such tenets.

To sum up the current discussion, we endeavoured to define the relation between the "whole" (τὸ πᾶν) and the one (or several) world systems inhabiting it. From the Atomists' perspective, the former is infinitely extended, and filled with an unlimited number of worlds, separated by vast expanses of void and "unorganized" atoms. In contrast, Aristotle's Cosmos is unique and includes the complement of material things,[69] and there is nothing, not even empty space beyond it. In other words, the whole is identical with the Cosmos and Aristotle regards both of them as finite in extent.

II.2 Arguments in favour of the infiniteness of space

Having defined our subject matter this way, let us proceed and analyse the actual arguments in favour or against the infinity of space. Firstly, I will start with the

[69] Here, a few words must be mentioned concerning Aristotle's divinity, the so-called "first mover" (τὸ πρῶτον κινοῦν), who directly causes the rotation of the outermost heavenly sphere. Strictly speaking, this entity, by virtue of lacking in any kinds of material parts, is not present in the physical universe (Aristotle, *Physics*, 267b17-26). In brief, Aristotle introduces it as some kind of eternally existing, non-material cause for the rotation of the heavens. For more on the "first mover", see: Solmsen, 1960, pg 222-249; Kahn, 1985.

Atomists, and have a look at what they say about the reasons substantiating the unlimitedness of the universe. In the course of this investigation, I will include and comment on Aristotle's criticism, whenever it is relevant.

The Atomists held that space is infinitely extended in all directions, and is filled by atoms (which they considered an absolute *plenum*) and empty space or "void" (κενὸν).[70] Let us look at some of the arguments they provided in support of the infinity of space. Epicurus demonstrates that the "whole" (τὸ πᾶν) cannot be finite, so, by necessity, it must be infinite:

"Again, the sum of things is infinite. For what is finite has an extremity, and the 'extremity' (ἄκρον) of anything is discerned only by comparison with something else. Hence, since it has no extremity, it has no 'limit' (πέρᾰς); and, since it has no limit, it must be unlimited or infinite."[71]

The argument can be reconstructed in the following way: 1, A finite thing has an "extremity" (ἄκρον), which can only be discerned by comparing it to something else; 2, the whole cannot be discerned by comparing it to something besides it (since it includes everything). From (1,) and (2,) follows: 3, the whole does not have an extremity (since there is nothing to compare it to). Having no extremity, it has no "limit" (πέρᾰς), and not having a limit entails that the whole must be unlimited and infinite in extent.

Aristotle, in his *Physics*, furnishes a possible counter-argument, saying that "being finite" (πεπέρασμενον) and "being in contact" (ἅπτεσθαι) should be distinguished.[72] The latter means that something is in a spatial relation to another object, whereas "being finite" does not involve such a relation to an exterior object. Aristotle appears to be right in pointing out this distinction. In fact, Aristotle`s definition of limitedness and "limit" (πέρᾰς) reaffirms this, since it certainly makes no reference to any exterior object, by dint of which the limit must be distinguished:

[70] Diogenes Laertius, ix.31.
[71] Diogenes Laertius, x.41.
[72] Aristotle, *Physics*, 208a10-14.

"The furthest part of each thing, and the first point outside which no part of a thing can be found, and the first point within which all parts are contained."[73]

However, scholars tend to differ as to whether, by revealing the difference between limitedness and "being in contact", Aristotle succeeds in invalidating the above argument or not.[74] In my opinion, Aristotle does succeed in undermining the argument. For (3,) results from (2,) by virtue of the "whole" not having anything besides with which it can have contact. Further, since (1,) asserts that a finite thing`s "limit" (ἄκρον) needs something outside to be compared to, it follows that Aristotle objection harms both (1,) and (2,) in such a way that (3,) does not result. Consequently, Epicurus` final conclusion that τὸ πᾶν cannot be finite does not hold either. On the other hand, Aristotle`s additional claim that *"…it's not like anything can be in contact with just anything…"* has little to do with the argument at hand.[75] Putting aside the above considerations, I have my doubts about the close rapport of the passages in question. What I mean is that Epicurus seems to be unaware of Aristotle`s distinction when phrasing his own argument.[76]

With respect to the earliest Atomists, due to the scant textual evidence, it is more difficult to ascertain the reasons why they held the "universe" (τὸ πᾶν) to be infinite.[77] Relying on a controversial passage of Aristotle (*De Generatione et Corruptione*, 315b6-14) Bailey writes that Leucippus reasoned in the following manner: since nature produces an infinite variety of phenomena, there must be infinite kinds of "shapes" (σχῆματα) to account for such diversity. In addition, the infinite variety of shapes also entails that the number of atoms ought to be infinite as well. [78] From this, Bailey argues, it follows that the universe must be infinite as well. However, this latter deduction is not even present in the discussed passage.

[73] Aristotle, *Metaphysics*, 1022a4-6.
[74] Some, like Sorabji or Furley, assert that Aristotle effectively objects to the Epicurean argument, whereas others, like Hussey, argue that, although limitedness certainly differs from "being in contact", this does little harm to Epicurus' reasoning (Sorabji, 1988, pg 136; Furley, 1987, pg 137; Hussey, 1983, pg 97).
[75] Aristotle, *Physics*, 208a13; Hussey, 1983, pg 97.
[76] Sorabji, 1988, pg 136; There are instances when Epicurus does demonstrate an awareness of Aristotle's objections, and constructs his argument (even going as far as modifying the Atomists' theory) accordingly. For an example of such as argument, see: pg 58-60.
[77] Asmis, 1984, pg 266.
[78] Bailey, 1928, pg 77; As we have already argued, the idea that physical laws can be readily deduced from the information provided by our senses is prevalent in Atomism.

Furthermore, Asmis questions the validity of Aristotle's account by suggesting that this might not even be the original argument of the Atomists. Asmis argues that the Atomists postulated the infinite variety of atomic shapes rather from the following: since there is no reason for the atoms to acquire any particular shape, there must be an unlimited number of them corresponding to the infinite multitude of atoms. This "no more this than that" principle is invoked rather frequently in Atomism, and we will encounter with it several times during my analysis. With respect to the questionable validity of Aristotle`s account (*De Generatione et Corruptione*, 315b6-316a14), scholarly opinion is divided. It would be too lengthy to elaborate the matter fully, but I tend to agree with Furley, and consider the whole passage as no less reliable than other sources. First of all, it contains information on the Atomists which does not contradict other sources. Furthermore, several well-attested Atomic ideas are expounded here, such as the "indivisibility of matter" or the role of atoms in explaining "coming-to be" (γένεσις) and "change" (ἀλλοίωσις). For this reason, most ancient and modern commentators rely on the passage in question. For instance, Lucretius seems to have Aristotle`s argument in mind when criticising the inference from infinitely varied phenomena to infinite "shapes" (σχῆματα). For he argues that the diversity of nature is certainly immense, but not infinite (Lucretius, *De Rerum Natura*, 2.660-729). In addition, through demonstrating how a finite set of letters can form a great variety of words, he refutes the deduction that "infinitely many shapes (of atoms) are required to explain the unlimited diversity of phenomena". Turning to the contemporary literature, Bailey consistently relies on the passage when considering infinite atomic shapes, and Cherniss also devotes several pages to discussing it.[79] Consequently, I see no reason to exclude this passage from the Aristotelian corpus of texts, which discuss the views of the Atomists. Therefore, I will continue relying on it in my work.[80]

Returning to our analysis of the content, as we have seen above, the inference of unlimited universe from the infinite number of atoms is not explicitly stated in Aristotle's passage. As a consequence, based on this passage solely, we have no right

[79] Bailey, 1928, pg 81; Cherniss, 1964, pg 112-4;

[80] For more information concerning this question, see: Asmis, 1984, pg 269-71; Furley, 1967, pg 83-4.

to attribute such reasoning to Leucippus. In fact, we must turn to Epicurus for this final step in the argument: if the "void" (κενὸν) were "limited" (ὡρισμένον), it could not accommodate the infinite multitude of atoms.[81] However, this is not necessarily true as it is shown in mathematics. If we look at the following number series,

$$1 + \frac{1}{2} + \frac{1}{4} + \frac{1}{8} \dots + \frac{1}{2^n}\ (n \mapsto \infty)$$

it will converge, and never reach the infinite. If we substitute the relative size of an atom for each member of the series, it is evident that their total size would be finite. Consequently, even a finite universe can accommodate infinitely many atoms. However, the above entails that the size of atoms converges to "0". Hence, there would be no lower limit to the size of atoms. This latter proposition falls dangerously close to the notion of infinite divisibility (of matter), which was resolutely refused by the Atomists.[82]

In fact, Epicurus does seem to reject the possibility of infinitely small atoms on the grounds that they must serve as "terminations" for the division of physical bodies.[83] Themselves being "uncuttable" (ἄτομος), they can no longer be sub-divided, so the process must terminate at the level of the atoms. In addition, in order to fulfil their intended function (to preclude infinite divisibility), the atoms cannot be arbitrarily small either. Otherwise, by taking ever smaller and smaller atoms, the process of division would never end. In other words, there must be a lower limit for their magnitude. Consequently, assuming the existence of such a limit for the Epicurean atoms, an infinite universe is indeed required to be able to accommodate them. As Epicurus rightly observes, nothing finite can contain an infinite number of parts no

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[81] Diog. L., x.42.

[82] I will address the question of divisibility in chapter IV. In brief, the Atomists held that all division must terminate at the level of atoms, which themselves are indivisible, whereas Aristotle argued that all physical objects are divisible *ad infinitum*.

[83] Bailey, 1928, pg 282-3; Asmis, 1984, pg 252-3; Diog. L., x.56-9; The Atomists argued that the division of a physical object cannot proceed *ad infinitum*, otherwise this process would result in the complete annihilation of the thing divided. Their reason seems to be that the never-ending sub-division of the material particles would push them into oblivion. I will discuss whether their statement is sufficiently supported in chapter IV.

matter how miniscule those parts are (provided that there is a lower limit to their size).[84] However, this argument is dependent on the Epicurean notion that the primary bodies are infinite in number, and cannot be arbitrarily small. If we do not accept such a notion (and Aristotle certainly rejected it), we should not accept the conclusion that the universe is infinite either.

There is another well-known argument in favour of the un-limitedness of space, which might be linked to the Atomists as well. Supposedly, it is attributed to the Pythagorean Archytas, and recounted by Simplicius.[85] Whether Democritus used it or not is uncertain. Nevertheless, the Epicurean Lucretius undoubtedly relied on a modified version of the argument in his *De Rerum Natura*.[86] Basically, Archytas conducts a thought experiment, in which a supposed observer stands at the edge of the universe (the whole), and tries to stretch his hand outside. Archytas envisages three possible outcomes: 1, one is unable to stretch out his or her hand; 2/a, one is able to perform the action, but is thwarted by something outside (presumably by a body); 2/b, without being obstructed, one reaches outside of the universe into empty space. According to Archytas, to be unable to stretch out a hand is counter-intuitive, so he outright rejects (1,). Therefore, only (2/a,) and (2/b,) remain as options. Since the presence of either an obstructing object or empty space implies that there is still something outside, one still hasn`t reached the edge of the universe and can proceed further out. No matter how many times this process is repeated, one would still find something beyond. So, in conclusion, the universe does not possess an extremity, and is unlimited.

This is a perplexing argument for the "finitists", since it appeals to common sense, based on which we (just like Archytas) feel compelled to reject (1,) as being absurd. In fact, I will demonstrate that, as long as we regard space as "conventional" (see: further down), it feels expressly counter-intuitive to reject Archytas' reasoning. As a result of being so appealing, this little thought experiment has elicited several

[84] Diog. L., x.57.
[85] Simplicius, *On Aristotle Physics*, 467, 25-30.
[86] Lucretius, *De Rerum Natura*, 1.968-79; Since Archytas was a contemporary of Democritus, scholars tend to believe that Democritus was probably aware of the argument and used it himself as well. For more on this question, see: Barnes, 1982, pg 59; Furley, 1987, pg 137.

responses since antiquity, and Aristotle also seems to be perplexed by its implications. He refers to it in the *Physics*, and furnishes a rather succinct counter-argument later on in the concluding chapter of book III.[87] It has received a mixed reception from modern scholars, and I tend to agree with those who assert that Aristotle fails to provide a convincing answer to Archytas' argument. Let us see why.

Aristotle avoids attacking the actual statements in the reasoning, and he takes a different approach instead by questioning the intuitive notion of space as something which never "gives out in the mind" (νοήσει μὴ ὑπολείπειν).[88] In my view, the two statements that: (A) "the region beyond the universe is infinite, because it does not 'give out' (ὑπολείπειν) in thought", and (B) "it is 'absurd' (ἄτοπον), that one, standing on the edge of the universe, cannot stretch out a stick" (for this latter statement, see: (1,) on page 31) are not identical. Although both statements depend on the presence of space beyond the edge of the universe, the latter one possesses a kind of intuitive appeal, which makes it difficult to reject it. Since the *Physics* tackles (A), it cannot be regarded as a direct refutation of Archytas' argument, which maintains (B). Moreover, even considering statement (A), Aristotle still remains inconclusive. Through an example, he tries to demonstrate that the fact that we can always imagine something does not entail that the thing is actually possible.[89] However, Aristotle also relies on thought and imagination, when constructing his own theory about the finiteness of the universe, so he has no grounds to criticise others for doing the same thing. Consequently, as I see it, Aristotle does not disprove anything, and he is even less successful in taking away the intuitive appeal of Archytas' argument.[90]

For this reason, several ancient expositors of Aristotle were dissatisfied with the succinct account of the *Physics*, and attempted to tackle the question in a more direct manner. Simplicius, after reporting Archytas' argument, also endeavours to refute it.

"So if, having reached the expanse of the 'heavens' (οὐρανός), he were to stretch out his hand, where would it be stretched out? Surely not into 'nothing' (μηδέν), for no

[87] Aristotle, *Physics*, 203b22-25, 208a14-20.
[88] In the *Physics*, this particular argument is mentioned in 203b24-5, and refuted in 208a14-20.
[89] Aristotle, *Physics*, 208a16-19.
[90] Furley, 1987, pg 137.

existing thing is in what does not exist. But nor will it be prevented from stretching out for it also cannot be prevented by what is nothing"[91]

The passage states that there is literally "nothing" (μηδέν) outside of the universe, and for this reason, one cannot stretch out his hand. However, the dual assertion that, due to this nothingness, one can neither stretch out his hand nor is one prevented from performing the action appears to be contradictory at first glance. After all, if I am unable to stretch out my hand into the "nothingness" (μηδέν), then, in a sense, this lack of space (the "nothingness") hampers me. However, Simplicius apparently denies this latter statement. He seems to regard the idea of trying to stretch something into "what does not exist" (τὸ μὴ ὄν) as illogical. However, for the one performing the action, it makes no difference what kind of obstruction lies beyond the edge of the universe. Whether there is absolutely nothing there, or some kind of invisible and impenetrable wall, it yields the same outcome. For, in either case, standing adequately close to the border of the universe, I start off my hand from within. Gradually getting closer and closer, my hand is halted as soon as I reach the border. Since throughout the whole time the entirety of my hand remains within the universe (in normal space), the nature of the obstacle lying beyond the edge does not change my subjective experience: if it is something which I cannot penetrate, it stops my hand all the same.

Alexander appears to be more resolute in the matter, since he straightforwardly states that it is the lack of space, which prevents one from stretching his hand outside of the "universe" (τὸ πᾶν).[92] However, his additional claim that "nothing would have any desire to stretch any of its limbs into nothing" seems to connect two entirely unrelated things. After all, how can the lack of space deprive me of an intrinsic desire to stretch out my hand into a particular direction? At least in "normal" space, such a causal relationship is impossible. I think that Sorabji errs in assuming that one cannot even initiate the action, since it would presuppose the existence of something concrete beyond the universe.[93] As shown by the above example, before acting, I am still within the universe (in normal space), and facing the edge, I just simply decide to

[91] Simplicius, *On Aristotle Physics*, 467, 37-468, 3.
[92] Alexander, *Quaestiones*, 3.12, 106, 35-107, 4.
[93] Sorabji, 1988, pg 127.

stretch out my hand. No matter how I look at it, the supposition that I cannot even initiate such an act seems illogical. After all, as long as I am in normal space (let us say, a few centimetres from the supposed edge), the possibility of there being absolutely "nothing" (μηδέν) beyond the edge cannot prevent me from moving my hand in any direction whatsoever.

All in all, both Aristotle`s argument in the *Physics* and the ones mentioned in the previous paragraph work well only within Aristotle`s own system. In his *Physics*, Aristotle defines the "place" (τόπος) of an object as the "limits of the surrounding body" (τὸ πέρας τοῦ περιέχοντος σώματος).[94] Such a definition of place precludes the existence of any kind of space outside of the "universe" (τὸ πᾶν) by virtue of τὸ πᾶν (the sum of things) having no body outside to serve as a limit and "place" (τόπος).[95] Both Simplicius and Alexander are thinking in Aristotelian terms, when insisting that there is nothing (neither body nor void) outside of the universe. However, since neither we nor the Atomists are committed to accept Aristotle`s definition of place, ultimately, all the above mentioned counter-arguments fail to disprove the infinity of space, let alone invalidate Archytas' reasoning.

Some scholars, who feel that Archytas' argument has been successfully invalidated, tend to appeal to modern physics and its concept of space. They argue that, just as the surface of a ball lacks any two dimensional boundaries, the three dimensional universe might also possess a shape lacking an "edge".[96] However, both Archytas and his opponents held a more "conventional" view of space. For them the universe was not "curved" or "closed" as modern physics tells us, but possessed a shape similar to a regular three dimensional geometrical object (for instance, the Aristotelian world system has the shape of a perfect sphere). The modern notion of space-time with its ability to be bent by gravity was most probably also alien to them. So, for this reason, I will consistently abstain from refuting or corroborating arguments in my study with

[94] Aristotle, *Physics*, 212a5-6.

[95] King, 1950, pg 77; Sorabji, 1988, pg 127-8; In addition, this definition also renders the existence of empty space as an impossibility, since it prescribes that all body must be surrounded by some other external object, and not by empty space. Therefore, in Aristotle`s world-system, there can be neither plenum nor void outside of the universe. Aristotle`s account of place (τόπος) is complex, and requires a more detailed consideration, which I will undertake elsewhere (see: chapter III, pg 106-11).

[96] Barnes, 1982, pg 60; Sorabji, 1988, pg 126.

our present-day speculations on the nature and shape of space. In my analysis, I regard the shape and nature of space as "conventional", which is what both Aristotle and the Atomists did. If we do this, and put aside the modern concept of a "curved space-time", Archytas' idea is invalidated neither by Aristotle's refutations, nor in a general sense.

That said, Archytas' argument still does not stand on a definite proof, which should be accepted without qualifications. However, assuming space to be conventional, which is what we agreed upon, it feels strongly counter-intuitive (and goes against experience), to reject the argument. For, let us suppose that the argument is wrong. In this case, if one sets out in a given direction, after a sufficiently long time, one would bump into an invisible wall at the edge of the finite universe.[97] One is not compelled to regard such an outcome as absurd (this is what I mean by saying that the argument is not a "definite proof" for the infiniteness of space). However, for my part, I find it hard to accept it. After all, in our everyday experience we do not encounter invisible walls or obstacles, which completely block our movement in a given direction. Therefore, I feel much more inclined to accept Archytas' reasoning than to reject it. Consequently, since Archytas' argument was likely adopted by the Atomists as well (see: note 86), in my eyes, they manage to prove the following: if space were conventional everywhere, it must be infinite. Moreover, this proof is effective even against Aristotle, since both he and the Atomists regarded space as conventional.

All in all, Aristotle fails to refute directly the above arguments, which were put forward by the Atomists to demonstrate the infinity of space. Although he successfully undermines one argument (Diog. L., x.41) by pointing out the difference between "limitedness" and "being in contact", neither Aristotle nor his successors manage to convincingly rebut the other arguments (for instance, that of Archytas).

II.3 Introduction to Aristotle`s arguments

[97] Remember that our space is conventional, and neither curves nor expands.

So far, I have concentrated on the Atomists, and only mentioned Aristotle where his criticism was relevant. Now, let us find out how Aristotle fares in defending his own standpoint, the limitedness of the universe. However, before commencing the actual analysis, a few general considerations must be mentioned in advance, which are required for the proper understanding of Aristotle's reasoning. Here, I will mention some points considering Aristotle's method of inquiry in the *Physics* and *De Caelo*, to which I will refer back later on under my discussion of the relevant passages. Then, still prior to the actual analysis, I will say a few words concerning Aristotle's overall attitude to infinite extensions in general, which will facilitate the understanding of his arguments against the possibility of such an extension (infinite space). In this respect, I will argue that Aristotle not only rejects the possibility of an unlimited extension, but also holds that there cannot even be an arbitrarily large extension exceeding any definite magnitude. First, I will discuss Aristotle's method of inquiry. With respect to the treatises in question, Aristotle's method can be categorized into "dialectic" and "scientific". In brief, the former applies a "deduction" (συλλογιμός), which relies on "premises" (πρότασεις), which are "opinions" (ἐνδόξα), entertained by the many or the wise.[98] In other words, dialectic reasons from things such as commonly held opinions or assumptions of renowned thinkers. On the other hand, scientific argumentation involves a different kind of deduction, called "demonstration" (ἀπόδειξις), whose premises are either "first principles" (ἀρχαι), or statements derived from these by means of previous demonstrations.[99]

Furthermore, so as to render dialectic argumentation applicable in a wide variety of subjects, its propositions must be "much generalized" (μάλιστα καθόλου), whereas

[98] Aristotle, *Topics*, 100a30, 104a8-11.

[99] *ibid*., 100a27-310; In the *Posterior Analytics* (71b20-72a9), Aristotle sums up the general characteristics, which first principles (of demonstrations) ought to possess. In brief, they must be "indemonstrable" (ἀναπόδεικτος), "first" (πρῶτος) and "immediate" (ἄμεσος), meaning that they cannot be demonstrated, and there is nothing prior to them in a causal sense. Instead, they function as primary causes underlying all other premises in any scientific demonstration. The indemonstrable nature of first principles entails a dual corollary: firstly, since they cannot be deduced, they can only be established through "induction" (ἐπαγωγή), proceeding from particulars to universals. Secondly, by virtue of lacking an explanatory cause, first principles are self-evident, and must be apprehended by a specific faculty, which is akin to "intuition" (νοῦς) (*Post. Analytics*, 100b12).

proper scientific inquiry relies on premises specific to that particular science.[100] In addition, scientific theories, including all their statements, must be in accordance with "empirical observations" (τὰ φαινόμενα κατὰ τὴν αἴσθησιν), and Aristotle frequently stresses the importance of τὰ φαινόμενα as a final check on theories.[101] In other words, a potent scientific argument always makes use of the available empirical data to validate its conclusions. In contrast, a dialectical argument relies on ἐνδόξα (popular opinion) to corroborate itself. Lastly, by virtue of being applicable in all the sciences, dialectic method is suitable for evaluating the validity of "first principles" (ἀρχαὶ) of each science, since, being primary and indemonstrable, these cannot be verified by scientific demonstration. Furthermore, dialectic is also useful in comparing and contrasting the different "views" (δόξαι) pertaining to a particular question.[102]

Since both the *Physics* and *De Caelo* cover scientific questions, one might reasonably expect that, predominantly, they exploit the scientific type of argumentation mentioned above. However, this is clearly not the case, and there are numerous instances, where Aristotle reasons dialectically.[103] In fact, some scholars argue that Aristotle fails to conform to the rules of proper scientific inquiry as laid down in his *Posterior Analytics*, since his reasoning is essentially dialectic.[104] This question is debated among scholars, and a detailed investigation would not be relevant to my work. Nonetheless, as I have said, I tend to agree with those who assert that Aristotle uses both scientific and dialectic methods, and in my analysis of Aristotle's arguments, I will indicate the type of method applied, wherever it is relevant.

Another distinctive feature of Aristotle's reasoning is the frequent reliance on certain *axioms* in explaining some of the conclusions. I am referring to assumptions concerning natural motion and rest, or certain notions concerning the elements.

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[100] *ibid*., 105b30-4; Bolton, 2009, pg 76.
[101] Aristotle, *De Caelo*, 306a16-8; *Prior Analytics*, 46a17-22; Bolton, 2009, pg 52-3.
[102] Aristotle, *Topics*, 101a30-b1.
[103] *De Caelo*, 268a6-19, 269a19-32; *Physics*, 204b4-9.
[104] Owen, 1986; For an alternative view, which proposes a mixture of scientific and dialectic argumentation being used, see: Bolton, 2003 and especially 2009; Leggatt, 1995, pg 17. As for myself, I concur with this latter view, and, in my analysis, I will furnish examples for both kinds of argumentations.

These are akin to “first principles” (ἀρχαὶ) in the sense that, within the arguments, Aristotle regards them as self-evident proofs for his conclusions. Some examples for such first assumptions are: “there are simple motions, and their number is two” (*De Caelo*, 268b19-20);[105] “each simple body moves naturally to its own place” (*Physics*, 211a5).[106] Although Aristotle lays down a method (Post. Analytics, book II, chapter xix) describing how to reach first principles by means of “induction” (ἐπαγωγή), both the *Physics* and *De Caelo* say little about the origins of such first assumptions as “there are simple motions”.[107] Within the arguments considered in this work, Aristotle regards these assumptions concerning natural motion as self-evident proofs for many of his conclusions. In my analysis, I argue that neither we nor the Atomists are compelled to regard these suppositions as self-evident, and ascertaining their truth-value would require a detailed analysis of arguments found elsewhere. However, this work is not about motion and rest, so I am not intending to decide if Aristotle adequately proves such notions as “there are simple motions” or “all motions are either natural or contra-natural”. Therefore, in most cases, I will only mention if a particular reasoning hinges upon such a first assumption.

Besides the above described first assumptions, there are other suppositions, which fulfil the same explanatory function, but which Aristotle does spend a considerable time to establish through arguments. Examples for this latter type: In the *Physics*, such an example is the concept of “place”. Aristotle argues for his own interpretation of it (210b32-211a30), then, he applies it as an already proven *axiom* in subsequent arguments (214a16-216b20). In *De caelo*, Aristotle establishes the existence of αἰθήρ (269a2-b16), and frequently refers to it in subsequent arguments (especially in books I-II). Just as with first assumptions, such “already established notions” should not be taken for granted, and ascertaining their truth-value requires a detailed analysis of

105 I call such a statement “first assumption” following Leggatt (1995, pg 13), and because Aristotle refers to them as “πρῶτη ὑπόθεσις” (*De Caelo*, 274a34).

106 *De Caelo* relies on a somewhat different set of first assumptions than the *Physics*. An example for this difference is the assumption that “there are simple motions” (268b19-20), and its explanatory role in the subsequent argument for the existence of a fifth element (269a2-b16). For an extensive list of first assumptions used in *De Caelo*, see: Leggatt, 1995, pg 14.

107 Leggat, 1995, pg 15; Hussey, 1983, pg xxxiv; Although, Aristotle does argue from simple magnitudes (circular and straight lines) to simple motions, as we have seen, the existence of simple motions cannot be adequately explained through simple magnitudes. For the original argument, see: pg 16-7.

the arguments in which they were originally argued for. Therefore, I will only highlight those instances when a particular argument depends on such notions without endeavouring to test their veracity.

II.4 Arguments against the infiniteness of space

Having introduced some relevant points pertaining to Aristotle's method of inquiry, let us turn to the relevant passages. In this part of my work, I will look for "positive" arguments in favour of a finite universe. As we shall see, there are very few of these, and Aristotle spends most of his time proving his case indirectly, by demonstrating the impossibility of infinite space. As a consequence, most of the considered passages contain such indirect arguments. By and large, most of these arguments apply *reductio ad absurdum* by presupposing the infiniteness of space, and concluding in various absurdities, if this supposition holds true. The main body of Aristotle's refutations can be found in book III of the *Physics* (especially chapters 4-8) and *De Caelo* I.5-7.

With respect to these passages, the bulk of Aristotle's objections are directed against the notion of infinite body, and not against infinite space. The reason for this lies in the fact that Aristotle rejects the possibility of empty space, and argues at length against it.[108] Then, he presupposes his conclusion (that there is no void) when arguing against infinite space. Consequently, in Aristotle's view, the only possible way in which space can be unlimited is if body is also infinite.

Let us examine the passages in turn. I will start with an analysis of the *Physics*, then, I will turn to *De Caelo*. In the *Physics*, Aristotle enumerates five reasons why thinkers believe in the existence of some kind of infinite:

"The more plausible arguments for the existence of something infinite are five: the arguments (i) from time, since this is infinite; (ii) from the division of magnitudes (for mathematicians too make use of the infinite); (iii) that only so will coming-to-be and

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[108] Aristotle, *Physics*, book iv.6-9; I will consider the question of void in chapter III.

ceasing-to-be not give out, i.e. only if there is an infinite from which that which comes to be is subtracted; (iv) that what is limited always reaches a limit in relation to something, so that there can be no[ultimate] limits, since one thing must always reach a limit in relation to another; (v) above all, and most decisively, the argument which makes a common difficulty for all thinkers: because they do not give out in thought, number and mathematical magnitudes and what is outside the heavens all are thought to be infinite."[109]

In my analysis, I will mainly focus on those passages which concern some form of infinite spatial extension (body, empty space or abstract surfaces). Among the above reasons listed by Aristotle, (iv) and (v) are the ones which unquestionably refer to the possibility of some kind of limitless spatial extension, whereas the remaining concern other kinds of infinities. I have already considered (iv) in an earlier discussion (see: pages 27-8), and here, I just reiterate my conclusion: as I see it, by pointing out the distinction between "being finite" (πεπέρασμενον) and "being in contact" (ἅπτεσθαι), Aristotle does succeed in undermining the argument. The last one (v), depends on conceivability: the phrase "they do not give out in thought" (τῇ νοήσει μὴ ὑπολείπειν) means that for any given number, quantity or spatial extension, one can always conceive of a larger one. Consequently, there can be no limit with respect to these entities.[110] The above reasons for the belief in the infinite (i-v) are severally rejected by Aristotle (*Physics*, 208a5-23). This conclusion (208a5-23) and 203b15-25 constitute the frame of the *Physics'* main discussion concerning the infinite. The passages in-between elaborate some of the problems, such as the impossibility of a limitless extension in more detail.

Before getting further immersed in the analysis, let us clarify what Aristotle understands by "infinite (extension)" when arguing against it. The *Physics* (204a2-6) lists four distinct ways the infinite can be understood: 1, it is something whose nature is such that it cannot be traversed; 2, whose traversal is either incomplete; 3, or difficult; 4, something whose nature admits of traversal, but (in actuality) it cannot be traversed. Although it is not stated explicitly, it is this last sense (4,), which

[109] *ibid*., 203b15-25 (Hussey's translation).
[110] Hussey, 1983, pg 76.

Aristotle understands as "untraversable" (ἀδιέξοδον), when arguing against infinite extensions.[111]

In order to facilitate understanding of Aristotle's subsequent arguments, let us say a few words concerning his overall attitude towards infinite extensions in general.[112] As has been already mentioned, Aristotle rejects the existence of infinite three-dimensional extension. In effect, he rules out the possibility of infinite extensions of any kinds (lines and surfaces included). However, Aristotle's "finitism" in this respect seems to go even further than mere rejection. The relevant passages are located in the *Physics* (206b20-6; 207b17-21). Here, Aristotle argues for the idea that there cannot be (not even potentially) a "magnitude" (μέγεθος) which "exceeds" (ὑπερβάλλω) all finite magnitudes. As we shall see, this idea implies more than simple finitude. I will reconstruct Aristotle's argument in accordance with the latter passage (207b17-21), and supplement it as needed with the information from 206b20-6. The passage in question:

"Any magnitude of any size that can exist 'potentially' (δυνάμει) *can also exist 'actually'* (ἐνεργείᾳ)*, and so, since there is no infinite 'perceptible magnitude'* (μέγεθος αἰσθητόν)*, there can be no magnitude which exceeds every specified magnitude: that would mean that there was something larger than the universe."*

The argument can be reconstructed as follows: 1, if a magnitude with size X can exist "potentially" (δυνάμει), a magnitude with a corresponding size may also exist "actually" (ἐνεργείᾳ);[113] 2, no infinite "sense-perceptible body" (μέγεθος αἰσθητόν) can exist (this has been already shown in the previous chapter of the *Physics*); 3, no

[111] Hussey, 1983, pg 77-8.

[112] Besides extensions, Aristotle considers other kinds of entities as well. There are certain kinds if "infinites" which are accepted by Aristotle. Notably, he seems to admit that, in a specific sense, numbers, time and the number of divisions within physical matter are all infinite. For more information on the kind of infinite existence Aristotle attributes to these entities, see: Charlton, 1991; Hintikka, 1966; Lear, 1979; Sorabji, 1983, chapter 14.

[113] Here, the meaning of "potentiality" and "actuality" is relatively straightforward. Simply speaking, X exists "potentially" at a given time *t*, if it does not exist at *t*, but may exist at a time later than *t*. In other words, the realization of X's existence must be possible. In contrast, X exists actually at time *t*, if it already exists at *t*. Depending on the nature of the thing they refer to, "potentiality" and "actuality" can acquire other slightly different meanings as well. Aristotle describes the various meanings of these terms in his *Metaphysics* (book Θ).

magnitude can be greater than the universe. From the above, Aristotle concludes that "there cannot exist (neither potentially nor actually) a magnitude which exceeds a definite size" (4,).

This is not a direct argument for the finiteness of space. Therefore, I will only explain the reasoning without ascertaining its validity. By means of (1,), Aristotle rejects the possibility of those extensions which are too large to be actualized in reality. Supplementing (1,) with (2,) precludes the possibility of an infinite extension (this is still conventional "finitism"). However, by the addition of (3,), Aristotle introduces an upper size limit to any possible extension. This upper limit corresponds to the volume of the Aristotelian universe, which has the shape of a finite sphere. Consequently, the argument concludes that there cannot exist (neither potentially nor actually) a magnitude which exceeds the size of the universe (4,). The fact that even potential existence is denied for such magnitudes can be deduced from (1,), which prescribes that any potential extension must be realizable in reality. In addition, in the other relevant passage (206b20-6), Aristotle explicitly states that infinite magnitudes cannot exist (not even potentially), since no actual infinite body can be found in our world. To recapitulate, Aristotle not only rejects the possibility of any kind of infinite extension, but also holds that an extension for which there is not enough space in the universe (for instance, a straight line with a greater length that the diameter of the universe) is impossible.[114]

Now let us see how Aristotle fares in proving his own case. In his *Physics*, after he introduces some of the reasons attesting the ostensible possibility of something infinite (see: i-v on pages 39-40), Aristotle endeavours to refute the existence of an infinite spatial extension. The main body of his objections are divided into two distinct arguments (204b4-205a7; 205a8-b1). Based on the "method of inquiry", the first one is further organized into dialectical reasoning (introduced by the term λογικῶς (204b4-10)), and scientific reasoning (indicated by the word φυσικῶς (204b10-

[114] For a similar interpretation of these passages, see: Charlton, 1991, pg 129-131; Hussey, 1983, pg 90-91; Lear, 1979, pg 194-5.

a7)).[115] In λογικῶς, the definition of body, which is "to be bounded by a surface" (ἐπιπέδῳ ὡρισμένον), prohibits it from being infinite. Why does the definition of body have such a restrictive effect? In *De Caelo* (268a8-9), body is defined as a magnitude (μέγεθος), divisible (literally, a "divisible entity": τὸ διαιρετὸν) in 3 ways. Putting it into modern terms, a three dimensional magnitude. Since 204b4-10 provides no reason, which might explain why a surface or a spatial magnitude in general cannot be unlimited, looking exclusively at this passage, the argument is too limited to be convincing. Later on, we will see passages (*Physics*, 206a14-b27), where Aristotle does argue against and reject the possibility of any kind of infinite spatial magnitudes. These passages will also explain why, for Aristotle, infinite bodies cannot even be thought of.

In the "φυσικῶς" part (204b10-205a7), Aristotle distinguishes two cases, and refutes them separately: 1, when the supposed infinite body is composite (made out of more than one kind of element) (204b11-21); 2, when this body is simple (composed of only one type of element) (204b22-205a7). (1,) is further divided with respect to the number of constituent simple bodies. If this number is finite, either some or all the elements must be unlimited in extent in order to make the object infinite. Aristotle rejects the former case on the grounds that the elements must "always be in balance with each other" (ἰσάζειν ἀεὶ τἀναντία), so none of them can be infinite. For Aristotle supposes that the "powers" (δυνάμεις) of the elements are proportionate to one another. For instance, consider a finite amount of fire interacting with an infinite amount of air. Let us assume that fire is X times more powerful than air. Even if we make X arbitrarily large, as long as X is a finite number, the infinite air destroys all the fire (204b14-9). Although, Aristotle talks about one element "destroying" (φθερεῖ) the other, we can safely assume that he refers to "elemental transformations" (one element transforming into another). That's why Simplicius

[115] Owen, who regards the *Physics* as an essentially dialectical treatise, objects to 204b10-a7 being scientific. However, as I see it, the passage does exhibit some of the features of scientific argumentation. I will highlight some relevant examples in the actual analysis. Therefore, I see no reason to regard its method as entirely non-scientific. On the contrary, I think this passage is a nice example where Aristotle applies scientific and dialectic reasoning separately within the same argument. Hussey also keeps the text's original distinction between λογικῶς and φυσικῶς types of reasoning (Owen, 1986, pg 251; Hussey, 1983, pg 79-80).

puts the notion as follows: "*But if air, for example, were unlimited but fire limited, the fire would be overcome by the air and 'transformed into it' (μεταβληθήσεται εἰς αὐτόν).*"[116] If we accept the notion of elemental change, Aristotle's reasoning seems correct. No matter how many times fire is more potent, by virtue of being limited, eventually it "will be used up" (ἐπιλείψει) (this happens thanks to the interaction with the inexhaustible supply of air), and the whole body will turn into air. In which case, it will no longer be composite, but simple.[117] In this argument, Aristotle makes only one element infinite while keeping the remaining finite. For the sake of proof, it is irrelevant whether we make one or more of the simple bodies unlimited, since, as long as there are finite elements as well, the balance will be upset, and the finite elements will be inevitably destroyed by their infinite "cousins". However, it is quite difficult to relate this argument to the Atomists, since they believed neither in Aristotle's elemental theory, nor in elemental change. Their atoms only interact through collisions, and they do not transform into one another. [118] Therefore, the above reasoning cannot refute the supposed existence of an infinite object made out of atoms (the primary stuff of the Atomists).

The proof through which Aristotle attempts to refute the possibility of "each of the (finite) number of constituent elements having an unlimited extension" is plain wrong.[119] Let us see why. From the fact that "material objects 'are extended' (διάστασαν) in all directions" (in modern terms, they are three-dimensional), Aristotle infers that "*an infinite body would be extended in all directions into the infinite*" (*Physics*, 204b20-2). However, in this case, there cannot be more than one infinite simple body, since, if bodies were extended in all directions into the infinite, even one of them would fill up all the available space, leaving no room for the other elements. Consequently, it is impossible that there is a body, in which each of the

[116] Simplicius, *On Aristotle Physics*, 478, 30-2; "Elemental transformations" refers to Aristotle's theory, according to which, when in contact, the elements change into one another. In brief, a "cyclical" process applies to the simple bodies, according to which the "neighbouring" elements, like fire and air, can transform into each other readily; whereas, the transformation of the more "remote" pairs, such as fire to water, takes longer (Aristotle, *De Generatione et Corruptione*, 331a7-b37).
[117] Simplicius, *On Aristotle Physics*, 479, 4-5.
[118]Aristotle, *De Generatione et Corruptione*, 325a24-b5.
[119] Hussey, 1983, pg 80.

finite number of constituent elements have an unlimited extension. This argument is clearly flawed: on the one hand, we can easily construct a body which is infinite in extent without being infinitely extended in all directions. For instance, an infinitely long rod with a diameter of 1 metre is only infinite in one direction. On the other hand, by supposing an infinitely extended "frame of reference", with each quarter filled completely with a different element, we can construct an infinite body constituted by the four elements, each having an unlimited extension (this is because all four quarters of our frame of reference have infinite volumes). Incidentally, it is interesting to observe that it is Aristotle's misconception that "infinite bodies are infinitely extended in all directions", which, occasionally, enables us to relate his arguments to infinite space. After all, when describing infinite space, we also imagine a vast emptiness infinite in all directions in a similar manner as Aristotle regards the extension of infinite bodies. Finally, one might notice that, in his argument (*Physics*, 204b10-205a7), Aristotle omits considering the possibility of an unlimited body comprised of infinitely many kinds of elements. However, as Simplicius points out, Aristotle already rejected the possibility of an infinite number of elements in book I of the *Physics* (187a12-b13).[120]

After rejecting the possibility of an infinite "composite" (σύνθετος) body (1,), Aristotle considers the case where this body is "simple" (ἁπλόος) (2,). Here, two cases are distinguished: 2/a, when this object is comprised of some other body besides the four elements (204b23-4); 2/b, when one of the Aristotelian elements is infinite (204b35-205a1). (2/b,) has already been rejected (see: 204b14-9) on the grounds that such an infinite element, by destroying the finite ones, would do away with elemental change. (2/a) supposes the existence of a simple body besides the conventional elements, out of which these latter are created.[121] However, if such a

[120] Simplicius, *On Aristotle Physics*, 479, 17-21.

[121] The fact that Aristotle introduces this "additional" element with "ὡς λέγουσί" (as (some) say) suggests that, here, Aristotle directly attacks some other thinker's theory. This "additional" element probably denotes Anaximander's "ἄπειρον". In brief, Anaximander supposed an additional element over and above the conventional ones, which served as a source for the generation and destruction of the latter. Simplicius' commentary also confirms that, here, Aristotle is arguing against Anaximander (Simplicius, *On Aristotle Physics*, 480, 1-4; Aristotle, *De Generatione et Corruptione*, 332a24-6; *Physics*, 187a20-2).

body were to exist, "it would be present in this world" (ἦν ἂν ἐνταῦθα) and perceptible by our senses. Since we cannot perceive it, there cannot be such an infinite body above the four elements (204b32-5). The reasoning might be regarded as an example of the "scientific" (φυσικῶς) method of argumentation. Strictly speaking, the argument is not "scientific", since its premises are not "first principles" (ἀρχαι) or statements derived from ἀρχαι. However, the method applied here is indeed "scientific" in so far as Aristotle rejects (2/a) by pointing out that it is at variance with empirical observations.[122]

Just as with his arguments against an unlimited composite body, Aristotle's objections against an infinite simple body also rely on his elemental theory.[123] If we accept it, then the requisites of elemental change indeed preclude the existence of any kind of infinite body. After all, in Aristotle's view, an object is either composite or simple, and, due to the laws of Aristotelian elemental theory, neither of these can be infinite in extent. However, modern physics tells us that material objects are not composed of the Aristotelian elements. Therefore, these arguments, which are essentially based on elemental change, cannot be regarded as conclusive. Against the Atomists, the above arguments do not work either, since the primary bodies of the Atomists (the atoms) behave in an entirely different manner: they only interact through collisions, and they do not transform into one another.[124]

After rejecting the possibility of an infinitely extended body (*Physics*, 204b4-205a7), Aristotle provides an additional counter-argument (205a8-b1). Firstly, he introduces the problem with a preliminary statement, according to which:

"*Every thing perceptible by sense is such as to be 'naturally' (πέφυκε) somewhere, and each such thing has a certain place, and the same place for a portion of it as for the whole of it: e.g. for the whole of the earth and a single clod, and for fire and a spark.*"[125]

[122] For more information on scientific argumentation, see: pg 36-37.
[123] See: (1,) and (2,) on page 43.
[124] Aristotle, *De Generatione et Corruptione*, 325a24-b5.
[125] 205a10-12 (Hussey's translation).

This follows from Aristotle's theory of motion: each material object has a tendency to move towards a certain place, which is its natural place, where the object is naturally at rest.[126] The fact that this place is called the "same for the whole and the part" (ὁ αὐτὸς τοῦ μορίου καὶ παντός), means that: although the place of the whole is obviously bigger than that of the part, both the whole object and its parts naturally tend towards the same place, and when reaching this place, they are naturally at rest there.[127] In addition, an object's place, which is the "inner surface of the surrounding body",[128] must exactly correspond to the object. It can neither be smaller nor larger than the object's volume.

After the preliminary statement, comes the actual argument where Aristotle applies a somewhat different distinction than in the previous argument. Firstly, he considers the case when the infinite object is "homogenous" (ὁμοειδές) (205a13-9). Then, the case, when this body is "not homogenous" (ἀνόμοιος) (205a19-b1).[129] Firstly, let us look at the former case when the supposed object is homogenous (composed of the same matter everywhere). Aristotle begins with a conditional statement: "if the infinite body is homogenous, it is either motionless or always in motion" (205a13). Why is that? Firstly, the motion referred to must be regarded as natural to the object. Secondly, the supposed body, by virtue of being infinite, must fill up all space. In other words, it must occupy the entirety of the universe.[130] However, aside from adducing its homogeneity, Aristotle does not explicitly explain why "an infinite homogenous body should either be at rest or move perpetually" (let (1,) denote this proposition). Nonetheless, it is possible to furnish an explanation for (1,) based on the argument in the *Physics*. We have seen that, in case of homogenous bodies, "the natural place

[126] For more on natural motion, see: pg 16-7.
[127] Ross, 1936, pg 550.
[128] For the definition of "place", see: Aristotle, *Physics*, 212a5-6.
[129] The previous argument (204b10-205a7) divided bodies into "composite" (σύνθετος) and "simple" (ἁπλόος). Here, a different distinction is implemented: being "homogenous" (ὁμοειδές) is not identical with being simple, neither is "not homogenous" (ἀνόμοιος) with composite. An object is homogenous if it is made out of the same material, and not homogenous if the material composition of its parts is different. In contrast, only those homogenous bodies are simple which are composed of one of the four elements. For instance, although a bronze sphere is homogenous, it is not simple. It is compound, since the bronze is composed of more than one element. In contrast, a chunk of earth is both homogenous and simple (Simplicius, *On Aristotle Physics*, 482, 28-483, 4).
[130] This follows from Aristotle's flawed notion that an unlimited object is extended infinitely in all directions (*Physics*, 204b20-2). For my refutation of it, see: pg 45.

of the whole and the part are similar in kind" (2,) (205a11). Following Simplicius (*On Aristotle Physics*, 483, 18-21), let us demonstrate this by taking an arbitrary part of the whole (let this be A), and inspect its behaviour. If A is at rest, it will not move (naturally) again. This follows from (2,), according to which all parts of space (including the one which A currently occupies) are similar, so there is no reason for A to change its place naturally. If A is already in motion, it will not come to a rest anywhere naturally either, because all parts of space are similar, and why should A stop here rather than there? Consequently, A will either remain at rest, or, if already in motion, keep moving indefinitely. In other words, (1,) applies.

After stating that a homogenous infinite body can only either be stationary or move incessantly (1,), Aristotle proceeds to reject both of these alternatives by raising some objections with respect to the movement of a "lump of matter" (βῶλος) within a supposed infinite body:[131] Where will this part move naturally or where it will be its natural rest (205a17-8)? If this part is naturally at rest everywhere, it will never move (205a18). If it is in motion everywhere, it will never stop (205a19). These two conditional statements require some explanation. The interpretation of "will rest everywhere" (πανταχοῦ μενεῖ), and "will be in motion everywhere" (πανταχοῦ κινηθήσεται) is difficult. In order to supply the intended meaning, the argument must be supplemented. Let us suppose that a portion X is naturally at rest somewhere (let this place be A). Since our homogenous infinite body fills up the whole universe, all parts of space are similar to A and natural to X. Therefore, X would be naturally at rest everywhere (not just in A), and will not budge, because it is already in its natural place. Since A was chosen arbitrarily, no matter where X stays (this is what "be at rest everywhere means"), it will never start moving.[132] Similarly, if X is in motion, it will never stop, because all parts of space are identical, and why here rather than there? Basically, in 205a18-9, Aristotle reaches the same conclusion as in his preliminary statement (this has already been considered on the previous page): "if the infinite

[131] *Physics*, 205a14-9; The "καίτοι ἀδυνατον…γὰρ" (and yet this is impossible…for…) in the beginning suggests that, in the following, Aristotle rejects the aforementioned two special cases (205a13) of a part (of the whole) "always moving" or "always at rest", and does not argue against movement (of parts within the infinite) in general. Ross' interpretation also confirms this fact (1936, pg 551).
[132] This interpretation is supported by both Ross (1936, pg 551) and Hussey (1983, pg 81).

body is homogenous, it is either motionless or always in motion" (205a13). The only difference is that, in 205a18-9, Aristotle demonstrates this conclusion with respect to an arbitrary portion of the infinite body. Nonetheless, since this portion was chosen arbitrarily, the conclusion can be applied to the whole infinite body as well. However, Aristotle regards both of the above alternatives as absurd due to the following:[133]

1, If all the parts of the homogenous infinite object are naturally at rest, and they never start moving by nature, it follows that there is no natural motion in general. Without natural motion, there can be no forced one either.[134] Consequently, in this case, there is no movement at all. However, this is an impossibility, since our senses tell us that some form of movement does exist.

2, In Aristotle's eyes, the case of "all parts moving incessantly within the infinite" is not possible either: Natural motion is direction oriented (earth moves towards the centre,…), but, according to Aristotle, in the infinite, the six directions of above, below, front, back, left and right cannot be designated in an absolute sense. This is what is meant by saying "why rather up or down or anywhere whatever (within the infinite)" (*Physics*, 205a14).

The things said under (2,) entail, that, for Aristotle, natural motion is impossible in any kind of infinite space (not just within an unlimited homogenous body) due to the impossibility of assigning directions in the infinite.[135] Whether it is feasible to assign direction in such a space or not, I will examine later on. For now, let us see what happens if our object is not homogenous (consists of parts dissimilar in their material composition) (205a19-b1). The number of such differing parts is either finite or infinite (a21-2). Against the former possibility, Aristotle uses the same counter-

[133] Although the reasons for this are not explicitly present in the argument, they would be fairly obvious for the reader familiar with the text and Aristotle's theory of natural motion. Nonetheless, in order to facilitate understanding, I will write down these reasons.
[134] Hussey, 1983, pg 81.
[135] Aristotle expresses his concern that "there can be no directions within the infinite" in more detail elsewhere in the *Physics*. For instance, in (205b31-5), and as part of an objection against infinite void (215a6-11). I will return to this question when considering these passages.

argument as in the case of composite unlimited bodies. I have already tackled this question with respect to composite bodies (204b14-9), so I will reiterate my conclusions only briefly.[136] Aristotle argues that, in case of a limited number of parts, one of them must be infinite, while the others must be finite in extent in order to exhaust the infinite object (205a23).[137] However, as we have already seen in 204b14-9, this is impossible, since the infinite part would inevitably destroy the finite ones, and terminate all kinds of change. This conclusion only holds true if we accept Aristotle's theory of elemental change. However, neither we nor the Atomists are compelled to accept this theory. In addition, Aristotle is wrong in excluding the possibility of "having a finite number of infinitely extended parts constituting the object" on the following grounds: On the one hand, Aristotle errs in his assumption that "an infinite body is infinitely extended in all directions". On the other hand, as I have already demonstrated (see: page 45), it is possible to conceive an object (the infinite "frame of reference"), which is comprised of a finite number of infinitely extended parts. All in all, this argument contains the same mistakes as the one Aristotle advances against composite infinite bodies.

We have considered the case, where the number of constituent parts of the infinite homogenous body are finite (205a22-5), so let us see what happens when these parts are infinite in number (205a25-6). This latter possibility is dismissed as well on the grounds that infinite dissimilar parts would require an infinite variety of elements (since each part should have a distinct material constitution), which is rejected by Aristotle elsewhere.[138] As we have seen, just like the previous argument (204b10-205a7), 205a8-b1 also relies on similar assumptions concerning natural motion and elemental change. Only the method of differentiation as applied to the objects is different. Here (205a8-b1), Aristotle divides objects into homogenous and non-

[136] For the original argument and my analysis of it, see: pg 43-5.
[137] Here (205a23), Aristotle makes a mistake. He uses the plural case, and talks about "some (more than one) parts being infinite" (ἔσται…τὰ…ἄπειρα), which is a possibility he rejects for different reasons. Therefore, the argument works better with the singular case: "one part being infinite, while the others are finite". This "modification" is justified by Aristotle himself, since he reverts to the singular case in the next line: "but such a thing (an infinite part) would destroy the opposites" (φθορὰ δὲ τὸ τοιοῦτον τοῖς ἐναντίοις).
[138] *De Caelo*, book III.4; *Physics*, 187a12-b13.

homogenous, whereas 204b10-205a7 distinguishes between composite and simple bodies. All in all, as I have already argued (see: page 46), neither we nor the Atomists are compelled to regard these assumptions as imperative. Furthermore, the above arguments (204b10-205b1) are directed against an infinite body filling up the whole available space, which is a concept entirely different from the Atomist world-system, where plenum (the atoms) and empty space together constitute the infinite universe. Therefore, in so far as Aristotle's arguments are directed against an infinite body filling up the whole universe, they cannot be regarded as direct refutations of the Atomists' ideas.

However, Aristotle has another counter-argument in store, which can be more damaging to Atomist Cosmology, since it is directed against all kinds of infinite spatial extensions (not just infinite material objects). The objection itself is as follows:

"every body perceptible by sense is in place, and the kinds and varieties of place are: above, below, forward, backward, right and left. These are not determined only relatively to us, and conventionally; they are so in the universe itself. But they cannot exist in the infinite."[139]

Aristotle holds that, within the universe, there are six directions (above, below, left, right, front and behind), which exist in two different ways. Besides being relative to an observer, these directions "are distinguished in the universe itself" (ἐν αὐτῷ τῷ ὅλῳ διώρισται). In any kind of space, they must exist in an absolute sense as well.[140] Another passage (*Physics*, 208b8-22) explicates the difference between "relative" and "absolute" directions in greater detail. In so far as they are "relative to us" (πρὸς ἡμᾶς) the directions do not remain the same, but change according to our position (208b15-6). For instance, if I turn 180 degrees, "front" and "behind" swap places. However, these directions exist in nature as well, "each being distinct and separate" (διώρισται χωρὶς ἕκαστον). For instance, the "universal" above is designated by the movement of light objects towards the circumference of the innermost heavenly

[139] *Physics*, 205b31-35 (Hussey's translation).
[140] Hussey, 1983, pg 100.

sphere, whereas "universal" below is the direction towards which all heavy objects move (the geometrical centre of the spherical Cosmos).[141]

However, according to Aristotle, since these directions cannot be defined in the infinite, there is no such thing as infinite space (205b35). From this, Aristotle concludes that there can be no infinitely extended body either (205b35-206a2). For each and every body must be in a place, which must possess the same extension as the occupying body.[142] Since there is no such thing as infinite space, there can be no infinite body either. This latter part of the argument (205b35-206a2) does not concern us, since it is directed against infinite bodies. However, what does concern us (and the Atomists) is the problem of assigning directions within the infinite, and whether the existence of these "absolute" directions is a necessary requisite for any kind of space or not. If not, then Aristotle's refutation fails, since infinite space can exist, even if we assume that none of the six directions can be designated within it. Within our inquiry, the pair of "upwards" and "downwards" fulfil a pivotal role, since natural motion, as understood by Aristotle, is dependent on them.

"*every body perceptible by sense has either heaviness or lightness and, if it is heavy, has a natural motion to the centre, and if it is light, upwards.*"[143]

Without "up" or "down" being designated, there can be no natural motion within the infinite, since bodies naturally move either upwards (towards the circumference) or downwards (to the centre of the universe). Since there are no such directions within the infinite, these natural motions are impossible. Without these two directions, in Aristotle's eyes, "heaviness" and "lightness" also lose their meaning, since he defines the former as "natural movement downwards (to the centre)", whereas the latter means "to move upwards (towards the circumference of the universe)".[144] Furthermore, without natural motion, there can be no motion at all within the infinite. For natural motion is the requisite of forced movement (its counterpart), and

[141] 208b19-22; Aristotle is less successful in providing definitions for the remaining 4 directions, and I will return to this question in chapter III.
[142] See: *Physics*, 211a1-2.
[143] *ibid.*, 205b26-8.
[144] *De Caelo*, 307b30-3, 308a29-32.

each motion is either natural or forced.[145] Consequently, a theory which does not account for natural movement is flawed in Aristotle's view. That's why he criticises the Atomists for not ascribing a natural motion to their atoms.[146]

Let us provide a list of Aristotle's above objections against infinite space:

A. Universal directions cannot be assigned in an infinite space.
B. Partly from (A), it follows that natural motions are impossible in an unlimited universe.
C. Without a universal up and down, how can the phenomena of heaviness and lightness be accounted for?
D. The Atomists fail to define a natural motion for their atoms.

Are the above objections effective against the Atomists? Is the existence of universal directions or natural motions essential for explaining phenomena? Obviously, Aristotle is wrong in assuming that "if not impeded, some objects fall downwards, because they are 'heavy', and heavy objects act in this way by nature; whereas some objects, if left alone, move in the opposite direction, since they are 'light', and light bodies naturally behave in this manner". It is the gravitational force, operating in accordance with Newton's laws of motion, which causes these movements. However, modern dynamics was unknown to the ancients, so Aristotle can hardly be criticised for providing a different explanation. On the contrary, in so far as we keep relatively close to the surface of the earth, and consider such simple motions as "the fall of a stone" or "the rise of a helium balloon", Aristotle's "centrifocal" theory accords well with observations.[147] Nonetheless, we all know that neither a universal centre nor absolute directions exist in our universe. Therefore, by alluding to their impossibility, Aristotle cannot refute infinite space.

[145] *ibid*., 301a21-6.
[146] *De Caelo*, 300b8-11.
[147] Due to the earth's gravitational pull, objects which are heavier than their environment fall towards the centre of the earth. Therefore they manifest the same motion which Aristotle attributes to heavy objects.

After the above general remarks, let us see what the Atomists have to say in face of Aristotle's objections. With respect to (A), based on the extant textual evidence, we can safely assume that neither Leucippus nor Democritus endeavoured to assign absolute directions within the "whole". However, as our own universe attests, the presence of Aristotle's absolute directions is not an indispensable attribute of space. What's more, such directions do not even exist in our universe (or, at least, there is no centre to serve as a focal point for the Aristotelian natural motions). In any case, since (A) does not hold, the Atomists are not required to answer it. Without (A), its conclusion that "natural motion is impossible in an infinite universe" (B) cannot be regarded as imperative (it might still be valid for some other unexpressed reason, but not in the context of the argument).

Concerning (C), how did the Atomists explain "heaviness" and "lightness" (why some objects fall down or up respectively)? After all, any proper explanation of this observed phenomenon seems to involve directions. So, lacking a universal "up" and "down", how can the Atomists account for this phenomenon? Since the vertical fall of bodies is something which was observed on the earth's surface, the majority of the relevant source material pertains to atoms within a world-system (preferably our own world), as opposed to the atoms situated outside of the Cosmos. Therefore, let us examine what occurs, when this downward fall (or rising up) occurs within our Cosmos.[148] We are all familiar with "free fall": all objects close to the earth's surface, which are heavier than their surroundings, tend downwards. According to Newton's second law, the "weight" of the object manifests itself as the resistance against this accelerating force (the earth's gravitational pull).[149] Some scholars argue that the atoms (of Democritus and Leucippus) lack an "innate" (or natural to use the Aristotelian term) downward motion, and their weight only manifests itself in the "vortex" (δίνη), which the Atomists used in explaining the formation of the

[148] It might be possible to take any arbitrary world-system, since Atomists believed in an infinite number of Cosmoi. However, for the sake of simplicity, let us stick with our own world.

[149] $\mathbf{F} = m \times \mathbf{g}$, where "m" is the weight of the object, "**g**" is the earth's acceleration, and "**F**" is the force exerted upon the object.

Cosmos.[150] The downwards fall of objects is supposed to be due to the "sorting" effect of this vortex, where "heavier" atoms accumulate at the "centre" (of the δίνη), and "lighter" ones are pushed towards the circumference. In other words, according to this view, the atoms have no weight outside of the Cosmos, and it is only when they are implicated in the vortex that the difference between heavier and lighter atoms is revealed.

However, as Aristotle rightly objects, it is hard to imagine how the sorting action of the vortex can explain the natural fall of objects:

"It is absurd too not to perceive that, while the whirling movement may have been responsible for the original coming together of the parts of earth at the centre, the question remains, why now do all heavy bodies move to the earth. For the whirl (δίνη) surely does not come near us."[151]

Here, Aristotle does not deny the ability of a whirl to accumulate heavy objects at its centre. Rather, he asks: since the whirl has already withdrawn to the outer parts of the Cosmos, presently, it cannot be responsible for the natural fall of objects. Therefore, if not the whirl, what is the cause?

It would prove to be too extensive to describe in detail the dynamism of such revolving systems. In brief, those ancient thinkers (like Empedocles or the Atomists), who used the δίνη to explain the accumulation of earth at the centre, probably observed how in whirlpools and eddies, heavier objects, due to their greater resistance, tend to collect around the central axis, whereas lighter ones are carried towards the circumference.[152] However, I agree with Furley, who maintains that this movement towards the central axis cannot be equated with the vertical fall of bodies,

[150] For this view, see: Bailey, 1928, pg 132; Burnet, 1920, pg 344-5; Guthrie, 1965, pg 403; In contrast, others argue that the weight of atoms must express itself even when they are not affected by the vortex (see: O'Brien, 1981 (the whole discussion is relevant); Furley, 1989, pg 91-102; Kirk, Raven, Schofield, 1983, pg 422). The question, in what other ways the atoms are shown to have weight, I will return to a bit later on.

[151] Aristotle, *De Caelo*, 295aa33-b1.

[152] For more information on the dynamism of the vortex, see: Ferguson, 1971; Tigner, 1974.

as observed on the earth's surface.[153] The Atomists believed the earth to be flat and "drum shaped",[154] which entails that the natural fall of objects occurs in parallel lines, perpendicular to the surface. This unique motion cannot be equated with the inward movement of heavy bodies, directed towards the central axis of the vortex. In fact, based on the textual evidence, it is not even clear whether Democritus or Leucippus themselves relied on their vortex model to explain the natural fall of heavy objects. In the Atomists' theory, describing the formation of the Cosmos,[155] we find that the vortex indeed forces lighter atoms outwards, whereas the heavier ones stay within the vortex: τὰ μὲν λεπτὰ χωρεῖν εἰς τὸ ἔξω κενόν, ὥσπερ διαττώμενα: τὰ δὲ λοιπὰ συμμένειν. In addition, this process is also responsible for the earth's formation at the centre of the whirl: ωὕτω γενέσθαι τὴν γῆν, συμμενόντων τῶν ἐνεχθέντων ἐπὶ τὸ μέσον.

However, this passage (Diog. L., ix.31-2) evidently refers to the initial stages of the world's formation, and its description of the "sorting of" lighter and heavier atoms cannot be applied to the natural fall (or rise) of bodies, as it is observed presently on the earth. Even Aristotle, when criticising the model, does not say that the Atomists (wrongly) explained natural fall in this manner. Rather, he criticises them for not providing any explanation: since the vortex is ill-suited to explain heaviness and lightness (the fall and rise of objects respectively), what is it, according to the Atomists' theory, which is responsible for this phenomenon (*De Caelo*, 295b3-8)? In a theory advocating an unlimited universe, it is not possible to define "up" and "down" in an absolute sense. Therefore, after the vortex has been deemed unsuitable, the Atomists lack any further means to elucidate the natural fall (and rise) of objects, which depend on these directions (*De Caelo*, 295b8-9). This is the same objection as mentioned in (A) on page 53. However, as we shall see in the case of Epicurus, it is possible to define an universal upwards and downwards even in infinite

[153] Furley, 1976, pg 87, 1987, pg 198, 1989, pg 95; Those, like Bailey or Burnet, who regard the "sorting" of the vortex as the cause for natural downwards fall, omit to explain how exactly this latter motion occurs within the whirl.
[154] Aetius, iii.10, iii.12; Bailey, 1936, pg 99, pg 152.
[155] Diogenes Laertius, ix.31-2.

space; a fact which enables Epicurus to assign a natural downward motion to his atoms, and escape Aristotle's criticism in this manner.

All in all, as long as the vortex is regarded as ill-suited to explain the fall of bodies (in this point, I agree with Aristotle and Furley), the Atomists are required to provide some different explanation. One such possibility would be to attribute a natural downwards movement to the atoms, just as Epicurus did. However, based on the available evidence, the question whether the primary bodies of Democritus or Leucippus had such a natural tendency or not is debated. As has been mentioned above, some scholars hold that, unlike in the Epicurean system, early Atomism attaches no natural movement to the primary bodies. Furthermore, these scholars regard the vortex model as the Atomists' sole explanation for the vertical fall of objects.[156] In contrast, Furley argues that, since it is absurd to assume that the vortex was used to explain this movement, the Atomists must have had some other explanation in store as well, which might well have been the atoms' natural tendency to fall downwards in parallel lines as found in Epicurus.[157] In my opinion, the evidence suggests that Democritus and Leucippus either assigned no natural (downward) motion to their atoms, or did not distinguish this motion clearly enough from movements resulting from the collision of atoms. If they did make a clear distinction, it is unlikely that Aristotle, who had access to the majority of Democritus' writings, would have said:

"Leucippus and Democritus, who say that the primary bodies are in perpetual movement in the void or infinite, may be asked to explain the manner of their motion and the kind of movement which is natural to them."[158]

This is the same objection mentioned under (D) on page 53, in which Aristotle criticises the Atomists for not being clear about the natural motion of their primary bodies. As further evidence, Simplicius also refers to Democritean atoms as having

[156] To list some among the propagators of this view: Bailey, 1928; Burnet, 1920; Guthrie, 1965; for a more detailed argument, see: O'Brien, 1981, pg 162-6.
[157] Furley, 1989, pg 91-102.
[158] *De Caelo*, 300b8-11.

no natural motion, and moving only by the force of previous collisions.[159] To sum up, looking at it in isolation from the other parts of the argument (A-D), Aristotle's objections (C) and (D) seem valid. In other words, it is probable that Democritus and Leucippus indeed did not distinguish the atoms' tendency to fall downwards from movements resulting from collisions. After excluding the vortex as a possible cause for vertical fall, and in light of the fact that the motion of compound bodies is defined by their constituent atoms, the early Atomists could well be asked to explain why do all objects either fall downwards or rise upwards if unimpeded? On the other hand, as we have seen, Aristotle' other objection (A), which says that "universal directions cannot be assigned in an infinite space", is ineffective both in general and against the Atomists. Due to its dependence on (A), this fact invalidates (B), which states that "natural motions are impossible in an unlimited universe".

Unlike the early Atomists, Epicurus had access to Aristotle's criticism, and some of the modifications he implemented in Atomist Cosmology could well be attributed to Aristotelian influence. Let us consider what Epicurus has to say against Aristotle's objections. Firstly, as a reply to (A), he describes a method by which "upwards" and "downwards" can be ascertained even in an infinite universe. At the same time, Epicurus attacks Aristotle on the grounds that Aristotle's own definition of these directions results in an absurdity.[160] Although there can be no "highest" (ἀνωτάτω) or "lowest" (κατώτατω) point within the infinite, it is still possible "to produce" (ἄγειν) a vertical line, extending from our feet into the infinite in both directions. [161] Here, the indefinite subjunctive with "ἄν" is used: to make this line "from wherever we stand" (ὅθεν ἂν στῶμεν). Hence, the line can be produced anywhere in space, and repeating the process would invariably result in parallel lines. In other words, Epicurus, having realized the impossibility of designating a highest or lowest point in

[159] Simplicius, *On Aristotle Physics*, 42, 10-1.
[160] Diogenes Laertius, x.60. Scholars also interpret this passage as Epicurus` reply to Aristotle`s objection (see: (A)), and an attack on Aristotle` own definition of the directions of "up" and "down" (Furley, 1976, pg 96-7; Konstan, 1972; Sorabji, 1988, pg 143-4).
[161] For a possible method to ascertain which direction is "downwards", one could take as a basis the natural motion of Epicurean atoms, which, if left undisturbed, "fall" in parallel lines in a given direction throughout the whole universe (Diogenes Laertius, x.61). Obviously, "upwards" is designated as the opposite direction.

the infinite (essentially this was what Aristotle objected to), defines a universal up and down, which are the same everywhere, and do not require a "top" and a "bottom". In the same time, Epicurus rejects Aristotle's definition, since it leads to an absurdity:[162] in the Aristotelian system, the line which signifies downward direction would be "both up and down with respect to the same thing" (ἅμα ἄνω τε εἶναι καὶ κάτω πρὸς τὸ αὐτό). In other words, an object moving in this way, would first move down, then up as it passes through the centre. This consequence is unacceptable for Epicurus, who seems to hold that, with respect to a point of reference, downwards (and upwards) should always remain the same: "taking an (appropriate) line, there must be only one up and one down on it" (ἔστι μίαν λαβεῖν φοράν τὴν ἄνω…καὶ μίαν τὴν κάτω). Consequently, regarding the lower part of this line as both up and down is impossible (this is what happens in Aristotle's system when this imagined line crosses the centre of the Cosmos).

To sum up our current discussion, Aristotle criticised the Atomists for not distinguishing the natural motion of atoms from other movements caused by collisions (see: (D) on page 53).[163] In reply to this, Epicurus clarified the Atomist standpoint, stating that, if left undisturbed, all atoms fall downwards in parallel lines through the void.[164] To render it in Aristotelian terms, this is their natural motion. In addition, this vertical fall of atoms is due to their "weight" (βάρος). Unlike in the case of the early Atomists, with Epicurus "weight" became a primary property of the atoms (besides "shape" (σχῆμα) and "size" (μέγεθος)).[165] However, a problem emerges if we define the atom's motion in the above manner. Namely, this motion seems to entail that the shape of the earth is more or less flat.[166] Nonetheless, this corollary of the atom's motion is not at variance with Atomist theory, since, as

[162] It is likely that the passage (Diog. L., x.60) contains an attack on Aristotle's method of defining "down" and "up" respectively as the centre and circumference of the Cosmos. For more on this question, see: Konstan, 1972, pg 270-1; Furley, 1976, pg 97.
[163] *De Caelo*, 300b8-11.
[164] Diogenes Laertius, x.61; Furley, 1976, pg 97.
[165] Diogenes Laertius, x.54; the notion that "atoms have weight" was probably introduced into Atomism by some other thinker (probably Nausiphanes) before Epicurus (Bailey, 1928, pg 289). Whether Democritus assigned weight as a property to his atoms, is controversial (see: pg 57-8).
[166] For the reasons, see: Furley, 1987, pg 197-8.

evidence suggests, the Atomists indeed believed in a flat earth.[167] Obviously, the earth's shape is not flat but spherical (or geoid to be more precise), and Aristotle, who held the earth to be spherical, adduces several examples, based on observations, which corroborate his own view (*De Caelo*, 297b17-298a8).

Ultimately, Aristotle's objections (A-D) fail to refute the possibility of infinite extension. As Epicurus has shown, the statement that "there can be no absolute directions within the infinite" (A) is false. Since, both (B) and (C) have (A) as their premise, they do not hold either. Epicurus can talk about the natural "downwards" motion of atoms, because there is a universal down and up, which are the same throughout his unlimited universe. By virtue of this fact, no matter where we are in the universe, we can assert that "all atoms naturally fall downwards (in parallel lines)". Consequently, in so far as the concept of "absolute directions" and that of "natural motion of primary bodies" are concerned, Epicurus was able to meet Aristotle's criticism. Some connected questions remain, such as: how can the Atomist explain heaviness and lightness? Why do bodies naturally move either up or down? What is it that underlies the differences of weight in compounds? Since these questions bear little or no relevance to my current topic, which concerns the size of the universe, I will not investigate them further. Here, let it suffice that Aristotle frequently criticises his predecessors (including the Atomists) for their theory of "weight" (for not being able to properly explain why some objects are heavier than others).[168]

In conclusion, the arguments of the *Physics* (book III, chapters 4-8) fail to conclusively prove the finiteness of space. As we have seen, all of these arguments are beset by certain problems, which render them inconclusive both in general and against the Atomists.[169] After discussing the *Physics*, let us examine the relevant arguments of *De Caelo* and see whether they prove to be more conclusive or not. The main

[167] Aetius, iii.10, iii.12; Bailey, 1936, pg 99, pg 152.

[168] Aristotle's theory of weight (and that of heaviness and lightness) is expounded in *De Caelo* (book IV.1-4). For a summary of the views of previous thinkers and Aristotle's criticism of them, see especially book IV.2.

[169] For a summary of the more common problems, consult the conclusion of this chapter.

argument is presented in book I.5-7, where, similarly as in the *Physics*, Aristotle spends most of his time arguing against the possibility of an infinite body (not that of infinite space). Aristotle indicates that this argument falls into two distinct parts with respect to the type of argumentation being used (274a19-24): in chapters 5 and 6, the supposed infinite body is considered "through its particular cases" (διά…κατὰ μέρος),[170] whereas chapter 7 approaches the question "in general" (καθόλου).

In a similar manner as in the *Physics* (204b11), Aristotle begins by applying the same distinction of "compound" (σύνθετος) and "simple" (ἁπλόος) to infinite bodies (271b17-8). However, unlike in the *Physics*, only the latter case is considered, since, as Aristotle rightly points out, the "limitedness of the simple bodies" precludes the existence of a composite infinite body:

"But it is clear, further, that if the simple bodies are finite, the composite must also be finite, since that which is composed of bodies finite both in number and in magnitude is itself finite in respect of number and magnitude: its quantity is in fact the same as that of the bodies which compose it."[171]

The volume of the whole must correspond to the total volume of its constituent parts. Therefore, if the latter is finite, the whole (the compound infinite body) is limited as well. Consequently, Aristotle proceeds to severally reject the cases of "regarding one or the other of the simple bodies as unlimited": the remainder of chapter 6 considers the possibility of an infinite αἰθήρ (271b26-273a6), whereas the beginning of the subsequent chapter is devoted to the sublunary elements (273a7-a20). Since these passages argue exclusively from the peculiar motions of the Aristotelian elements, they bear little or no relevance to our inquiry. They cannot convince us about the limitedness of our universe, since we know that matter does not follow the

[170] Although "μέρος" literally means "part", in this context, a special meaning of the word is required. Leggatt (1995) renders "μέρος" as "attribute" (see: 274a20 on page 71). However, I think that "case" coveys the meaning better: chapters 5 and 6 reject the particular "cases" of "taking one or the other of the Aristotelian elements as unlimited". For more on the methodology of these arguments and how it compares to Aristotle's general distinction between "dialectic" (λογικῶς) and "scientific" (φυσικῶς) methods, see: Leggatt, 1995, pg 187-8. On dialectic and scientific argumentation in general, see: pg 36-7.

[171] *De Caelo*, 271b19-23; that "the types of simple bodies are limited in number" is argued for elsewhere (*De Caelo*, book III.4), and Aristotle presupposes it throughout the argument.

movement of the Aristotelian elements. In addition, these arguments have no effect on Atomist cosmology either, since the Atomists do not attribute such motions to their primary bodies. For these reasons, I will only present here a brief summary of their content.[172]

Concerning the "first body" (αἰθήρ), the arguments (271b26-273a6) rely on two basic premises:

A. Αἰθήρ moves in a circle (271b27-8).
B. It is not possible to traverse an infinite distance (272a3).[173]

Based on these premises, Aristotle constructs several examples to show that no infinite body can move in a circle, because, in order to complete its revolution, it would need to traverse an infinite distance, which is precluded by (B). However our senses tell us that the heavens do revolve:

"Yet our eyes tell us that the heavens revolve in a circle, and by argument also we have determined that there is something to which circular movement belongs."[174]

Therefore, in order to account for the observed facts, this body (αἰθήρ) needs to be finite in extent. Just as with αἰθήρ, the natural motion of the sublunary elements precludes their infiniteness. Each of these bodies tends naturally either towards the centre or towards the inner circumference of the heavenly sphere. Since these points are "determined" (ὡρισμένον), the region in-between (in this case, the distance separating the two points) must also be determined and limited (273a15-6).[175]

[172] For a more detailed discussion, see Leggatt's commentary (1995, pg 189-92).
[173] For more on what Aristotle means by saying that the infinite "cannot be traversed" (ἀδύνατον διελθεῖν), see: Hussey, 1983, pg 77-8.
[174] *De Caelo*, 272a5-7; the expression "we see" (ὁρῶμεν) implies that, here, Aristotle applies the "scientific" argumentation, which requires from any proper theory to be in accordance with the observed facts (providing that our observations are reliable).
[175] In this context, τὸ μέσον refers to the distance (or space) separating the centre and the circumference. In its usual meaning, ὥρισται means "is determined". However, when it refers to the space in-between (τὸ μέσον ὥρισται), ὥρισται can be rendered as "is limited".

Finally, if the distance is finite, the bodies (the four elements) covering it ought to be finite as well (273a18-9).

After concluding that none of the simple bodies can be infinitely extended, Aristotle furnishes an additional argument (273a21-274a18), which is designed to show the impossibility of an unlimited body through the fact that such an object can neither possess "weight" nor "lightness". In order to appreciate the argument, some points which are not explicitly expressed in the passage must be mentioned beforehand. For any object, to be heavy means to "tend naturally towards the centre", whereas to be light means to "have this movement towards the circumference".[176] In addition, all material objects (apart from the element of "fire") must be endowed with weight (*De Caelo*, 311b5). Therefore, an infinite body must have weight as well.

Although the first half of the argument (273a21-b28) intends to demonstrate that "an unlimited body must have infinite weight (must be infinitely heavy)", as Aristotle points out, the same conclusions would hold true in the case of fire, which only possesses lightness (273a25-6). At first, Aristotle demonstrates that "an infinite body cannot have a finite weight" (273a21-b28). Then, he proceeds to refute the notion of "unlimited weight" (273b29-274a15). Hence, Aristotle concludes that since its weight cannot be finite and infinite weight is an impossibility, an unlimited body has no weight at all. However, this is impossible, since all objects possess weight. Consequently, none of them can be infinite.

Let us see the argument (273a21-274a18) in greater detail. The statement that "an infinite body must be infinitely heavy" appears to hold true in general (not just in Aristotle's system). The argument for it (273a27-b9) seems sound, and its conclusions hold. It would be too long to provide a detailed description of it here.[177] In brief, by means of *reductio ad absurdum*, Aristotle points out some impossible consequences of "having an infinite body with a finite weight". Let us regard the following equation:

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[176] For more on Aristotle's notion of weight and that of "heaviness" and "lightness", see: pg 21-2.
[177] For a more detailed analysis of the argument, see: Heath, T L, *Mathematics in Aristotle*, pg 166-7 (Oxford, 1921).

$$\frac{E}{C} = \frac{BD}{BF}$$

Here, “C” is the finite weight of the infinite body (let this body be “A”), “BD” and “BF” stand for the respective sizes of the subparts of “A”, and “E” is the weight of the sub-part whose size is “BD”. Supposing that there is a direct correlation between weight and size (the larger part is the heavier) (273b3), a ratio can be given between E and C (since C is finite). In such a case, based on the above equation, a suitable subpart with volume BF (let us denote this part as BF’) can be found, which is larger than the subpart whose size is BD. However, due to the correlation between weight and size, the weight of BF’ must be the same as C. In other words, BF’, being only a subpart of A, would be as heavy as A, which is impossible (273b5). Furthermore, since A is infinite, an even greater part (GB) can also be taken, which would be heavier than both BF’ and A, but it cannot be that a part is heavier than the whole (273b6-9). Consequently, these considerations show that an infinite body cannot possess a finite weight.

However, this argument works only in case of bodies with a “homogenous weight distribution” (ὁμοιοβαρὲς). Otherwise, by decreasing the “relative” weight of its substance *ad infinitum*, an unlimited body with a finite weight can be constructed. As Leggatt rightly observes, Aristotle fails to consider this case, when looking at infinite bodies with “non-uniform weight distribution” (ἀνομοιοβαρὲς).[178] For, if we imagine a body (let it be “X”) with an unlimited number of parts, whose weight corresponds to the infinite series of ($1, 1/2\, , 1/4\, , 1/8\,$, …), then the total weight of X would be finite, since the series itself is convergent and its sum tends towards “2”.

Putting aside the above refutation, in order to appreciate the subsequent argument, let us suppose that Aristotle is right in asserting that the weight of the infinite body is not limited, but unlimited. This latter possibility is also rejected on the grounds that an object with an infinite weight would not be able to move (273b29-274a15).

[178] *De Caelo*, 273b23-5; Leggatt, 1995, pg 193.

Aristotle argues that the time necessary to complete a given distance is "inversely" (ἀνάπαλιν) proportionate to the object's weight (273b31). In other words, the heavier the object the faster it moves towards its natural place.[179] For instance, if "X" completes "Y" distance in time "t", "2X" traverses "Y" in "1/2t". However, this is not possible in the case of the infinite body, since "the unlimited has no relation to the limited" (λόγος δ' οὔθεις ἐστι τοῦ ἀπείρου πρὸς τὸ πεπερασμένον). Therefore, the unlimited body would have to complete a given distance in infinitesimally short time, since there is no "smallest time unit" in which any object can complete a given distance (274a9). Even if there were such a smallest time unit, the argument still applies: let the time in which an infinite body with weight "A" covers a given distance be "z". Furthermore, let "X" be the weight of a finite body, which completes that same distance in "nz" (where n is finite). Since there is an inverse proportion between weight and time, the following holds:

$$\frac{A}{X} = \frac{nz}{z}$$

Since both X and n are finite, there is a finite weight (nX), which can be substituted for A. Consequently, a finite body with weight nX would move equally fast as our infinite body, with weight A. However, it is impossible for two bodies with differing weights to have the same speed (with respect to their natural downward movement). Since the possession of unlimited weight entails the above absurdities, there cannot be an infinitely heavy body. All in all, Aristotle concludes that an object can neither possess an unlimited weight nor unlimited lightness (274a16).

Although the above arguments (273a21-274a18) are certainly sound in their own right, they have no effect against the infinite universe of the Atomists. Firstly, they refer to infinite bodies, and cannot be applied to infinite space (after all, empty space

[179] In Aristotle's theory, the greater the quantity is the faster it moves towards its natural place. For instance, supposing a given altitude, more lead falls downwards with a greater speed than less lead (*De Caelo*, 309b10-5). Obviously, in the current argument, movement must be understood as "natural downwards motion", and such factors as "resistance of the medium" or "the object's shape" should be disregarded.

has no weight, while these arguments depend on the notion of weight). Secondly, as modern dynamics tells us, Aristotle is wrong in assuming that "a heavier object falls downwards faster than a lighter one", and, in fact, the Atomists (or at least Epicurus) held the opposite. According to Epicurus all atoms (irrespective of their size) fall naturally downwards with equal speeds within the void.[180]

After rejecting the existence of an unlimited body on the basis of certain "particular cases" (if this body is from αἰθήρ, if one of the sublunary elements is unlimited…), in chapter 7, Aristotle considers the "more general arguments".[181] He begins by stating that an infinite body has either "similar" or "dissimilar" parts (274a31).[182] In the latter case, the number of these parts are either limited or unlimited (274a33). That there is an infinite number of differing parts is straightaway rejected on the grounds that the number of elements cannot be infinite, a possibility which Aristotle rejects (274b1-4).[183] If the number of parts are limited, one (or more) of them has to be infinite in extent in order to make the whole body infinite. However, in chapter 6, Aristotle has already rejected the possibility of "one of the simple bodies being unlimited in extent". Consequently, there can be no infinite object with dissimilar parts.

Although the above would be enough to reach this conclusion, Aristotle provides an additional, and flawed argument (274b18-21). He assumes a scenario, when the various parts are "being dispersed" (διεσπασμένα) within the whole like the different fruits in a fruit cake (to adduce Leggatt's analogy). Hence, none of them is present in a "single mass" within the object. Aristotle argues that from the definition of body, which is "to be extended in all directions" (274b20), it follows that these parts, by

[180] Diogenes Laertius, x.61.

[181] For the distinction between the two kinds of approaches, see: pg 61.

[182] Although Aristotle here talks about parts being "similar" (ὁμοιομερές) or "dissimilar" (ἀνομοιομερές), the argument shows that, in fact, he applies a similar distinction as that between "composite" (σύνθετος) and "simple" (ἁπλόος) objects. In other words, "similar" or dissimilar" (in parts) refer to objects comprised of one or more elements respectively (see: Leggatt, 1995, pg 193). Therefore, the same distinction is implemented here as in the *Physics* (204b4-205a7; for the analysis of the passage, see: pg 43-6).

[183] Aristotle argues against the possibility of an infinite number of elements at a greater length in book III.4 of *De Caelo*.

virtue of being infinite, are "extended in all directions indefinitely".[184] In this case, there cannot be more of them (274b20-1), since even one of them would fill up all available space. However, Aristotle is clearly wrong. He disregards the fact that each part (let's say fire) is being dispersed, and divided into smaller bits, which are not necessarily infinite. After all, if we prescribe both a lower and an upper limit to their volume, and make them infinite in number, these smaller (finite) portions of fire would still add up to infinite.

After rejecting the possibility of an unlimited body with "dissimilar parts" (ἀνομοιομερές), Aristotle briefly considers the case, where this object has "similar parts" (ὁμοιομερές) (274b22-8). This latter possibility is also rejected on the following grounds:

1, having similar parts entails being comprised of the same matter all throughout. If this matter is one of the sublunary elements (αἰθήρ is not considered, since it possesses neither "heaviness" nor "lightness"), this leads to infinite weight or lightness, since the whole object is comprised of a particular element, which itself must be infinite as well. However, as has been shown, infinite weight (or lightness) is not possible.[185]

2, the body cannot be made out of the "fifth element" either, since, as has been already demonstrated in chapter 5 (271b26-273a6), "the body which moves in a circle (αἰθήρ) cannot be unlimited" (οὐδ᾽ οἷόν τε τὸ κύκλῳ σῶμα φερόμενον εἶναι ἄπειρον).

All in all, these arguments (274b5-28) can be resolved into Aristotle's notion that "all of the simple bodies must be limited, because, otherwise, they would be unable to

[184] Aristotle relies on this same inference, when arguing against composite infinite bodies in the *Physics* (204b20-2). There, I have already demonstrated (see: pg 45) that, in the case of infinite bodies, the inference from "being extended in all directions" to "being extended in all directions *ad infinitum*" is not necessarily true. After all, a body which is unlimited in only one direction (for instance, an infinitely long rod) still has an infinite volume.
[185] See: *De Caelo*, 273b29-274a18.

move", which is argued for in chapters 5 and 6. However, as I have already said, neither we nor the Atomists are compelled to accept Aristotle's ideas concerning "elemental motions". Therefore, the present arguments (274b5-28), which are ultimately based on such ideas, cannot be regarded as conclusive.

Aristotle proceeds with a brief explanation showing why an infinite body would be unable to move (274b29-b32). Motion presupposes both "natural" and "unnatural" movement.[186] Since these motions require places, to which they are directed, there must be both a natural and an unnatural place for the object. Since the body and its place have an identical volume, each of these places must be unlimited. Because of his misconception that "an infinite spatial extension is unlimited in all directions", Aristotle rejects this conclusion. However, as I have already demonstrated,[187] Aristotle is wrong in this, which renders the whole argument (intended to be a *reductio ad absurdum*) ineffective.

Next, Aristotle demonstrates that an unlimited body can neither "affect" nor "be affected" by another object (274b33-275b4). This refers to the infinite object's inability to either "cause" or "suffer" any kinds of "changes" (κινήσεις) whatsoever. In general, Aristotle distinguishes three kinds of "changes": change of "quantity" (for instance, to increase in size), of "quality" (for instance, changing from cold to hot), and that of "place" (*Physics*, 225b5-9).[188] From these, change of place (in other words, locomotion) has just been considered (see: chapters 5 and 6 of *De Caelo*). So, Aristotle turns to demonstrate an infinite body's inability for the remaining two kinds of change. Three cases are distinguished: 1, when a limited body "affects" an unlimited (275a1-13); 2, when the unlimited "changes" (κινήσει) the limited (275a14-23);[189] 3, when an infinite is "acted upon" (πάσχει) by another infinite body (275a24-b4).

[186] This follows from Aristotle's theory of natural motion, and is presupposed in the argument.
[187] See: pg 45.
[188] For more on Aristotle's classification of changes, see: *Physics*, book III.1 and V.2; *De Generatione et Corruptione*, I.4, 319b3-320a2. For some additional explanation, see: Hussey's (1983) notes on pages 56-8.
[189] Here, κινήσει can be rendered either as "it changes (something)", or as "it affects (something)".

Similarly as in his argument about the "weight of the infinite body" (273b29-274a15), here, Aristotle also exploits the basic idea that "the infinite stands in no ratio to the finite". In this case, Aristotle presupposes a correlation between the size of an object and the time it takes for the object to elicit a given change (275a21). For instance, if "X", "Y", and "Z" are bodies, and if X is smaller than Y, Y will change Z in a lesser time than X. Considering (1,), let an infinite body (A) be affected by a finite (B), and let "C" be the duration of this change (275a1-2). In addition, let's suppose another body (D), which is smaller than B, changing an even smaller object (E) in time C. Since the "size of the object" and "the time of change" are inversely proportionate (see: above), and both D and B cause change in time C, a certain limited body (Z) can be given, for which the following holds true:

$$\frac{size\ of\ D}{size\ of\ B} = \frac{size\ of\ E}{size\ of\ Z}$$

Therefore, a finite body (Z), is affected by B in time C. However, A, which is unlimited, is also changed by B in time C. Since it is impossible that B changes two objects with differing sizes under the same time, the unlimited cannot be affected by the limited (275a10-12).

With respect to the remaining two alternatives of "the unlimited affecting the limited" (2,), and that of "an infinite changing another infinite" (3,), Aristotle proceeds in a similar manner, and I will only mention the two conclusions, through which both alternatives are rejected. (2,) entails the impossibility of "the finite and the infinite altering the same body in an equal time" (275a19-20). With respect to (3,), it results in a "never-ending" change, which is rejected by Aristotle on the grounds that "all change must have an end (τέλος)".[190] All in all, in so far as these arguments hinge upon the notion that "the object's size is proportionate to its potency to affect change", they pose no threat to the Atomists. Even if their total volume were to be infinite, the atoms do not constitute a single mass, so their behaviour is not equivalent to a single object with an unlimited size.

[190] For Aristotle, all processes of change are limited and must terminate at some point (*De Caelo*, 277a16-26).

Then, in a rather "succinct" passage (275b5-11), Aristotle lists a few corollaries of the above conclusions. According to him, "all sense perceptible objects possess a capacity to affect or to be affected (or both)" (πᾶν σῶμα αἰσθητὸν ἔχει δύναμιν ποιητικὴν ἢ παθητικὴν ἢ ἄμφω). Since the above arguments showed the inability of the infinite to "change" or "be changed", the infinite does not possess such δύναμις. Therefore, all sense perceptibles must be limited (275b6). Furthermore, since only sense perceptible bodies are "in a place" (ἐν τόπῳ), an unlimited object has no place either. It follows that, there will be no unlimited body outside of the Cosmos, since being "outside" (ἔξω) also "signifies" (σημαίνει) "being in a place" (275b9),[191] and only finite bodies can have a place.

The subsequent arguments also consider unlimited bodies, and cannot be applied to our object of inquiry, which is "infinite space". Therefore, I will only list them briefly:[192] 1, (275b12-17) is just a brief reiteration of the arguments (271b26-273a20), which I have already considered on pages 61-2 ; 2, in (275b18-28), Aristotle argues that, in order to move an unlimited body "contrary to its nature", an infinite moving force is required, [193] which can only belong to an external unlimited object. Therefore, for the infinite to move in any manner, two separate unlimited objects need to exist (and interact) simultaneously. However, this is impossible on the grounds: a, in (275a24-b4), Aristotle already rejected the possibility of "the infinite affecting another infinite in any way"; b, an existence of a separate mover means that there are two unlimited spatial extensions existing simultaneously, a possibility which Aristotle rejects (see: pages 44-6).

After a brief passage (275b29-276a6) which is not relevant to infinite extension, Aristotle concludes chapter 7 with a final argument against unlimited space (276a6-

[191] Aristotle argues against the possibility of "having any kinds of physical body outside of the heavens" elsewhere (278b25-279a10). For my analysis of it, see: pg 23-4.
[192] For a more detailed commentary, see: Simplicius, *On the Heavens*; Leggatt, 1995, pg 195.
[193] Aristotle's argument seems to imply that both natural and unnatural movement demand an external mover (275b18-9). However, as Simplicius points out (*On the Heavens*, 240, 14-6), the presence of an external (unlimited) mover is only required in the case of "counter-natural" motion.

11). It is based on the objection, which has already been expressed in the *Physics* (205b30-5), that "no "centre" (μέσον) or "extremity" (ἔσχατόν) can be assigned within the infinite". Since, in Aristotle's view, upwards and downwards motion are directed to these places, they are also impossible in an unlimited universe. In a "space" lacking an absolute up or down (and the corresponding movements), there can be no motion at all (276a9-10).[194] As I have already mentioned, although there is no "centre" or "extremity" in the infinite, as Epicurus has demonstrated, it is still possible to designate universal upwards and downwards, and through these, it is possible to explain the motion of heavy and light objects even within an unlimited universe.[195]

II.5 Conclusion

To sum up, in my opinion, neither the arguments in favour nor against the infiniteness of space are compelling enough to make a definite standpoint. With respect to the former, due to the scant textual evidence, it is hard to come across reasons why the early Atomists believed the universe to be limitless. With respect to later Atomism, we had a look at several of their arguments, advocating the infiniteness of the universe. One of these, arguing from the unlimited multitude of atoms, only holds true if we accept the Epicurean system (otherwise, rejecting the premises of the reasoning destroys the argument).[196] Concerning another argument (Diogenes Laertius, x.41), Aristotle is at least partly successful in refuting it (see: pages 27-8). However, he fails to disprove the so called "Archytas" argument (see: pages 31-5), which possesses a kind of intuitive appeal, making it a compelling proposition: "it is counter-intuitive to assume that the universe has an edge, since, in that case, one passing through it would be blocked by something like an invisible wall; therefore, the universe cannot have an edge, and is infinite". However, the premise is based on common sense, and not on a definite proof. In fact, theoretical physics suggests that space (or space-time) might be curved (or closed), and not infinite in a classical sense.

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[194] There would be neither natural nor unnatural motion, since the latter is dependent upon the former, which is not possible without the directions upwards and downwards.

[195] For a more detailed explanation, see: pg 58-9.

[196] See: pg 30-1.

Although I would not go as far as to completely reject Archytas' idea, based on certain conjectures of modern physics.[197] To put it differently, from our modern day perspective, the argument might be objectionable. However, looking at it from the perspective of the ancients, who held a more conventional view of space, Archytas' idea is invalidated neither by Aristotle's refutations, nor in a general sense. What's more, supposing space to be as the ancients did, it feels more natural (and in accordance with ordinary experience) to accept Archytas' argument (and the infiniteness of space) than to reject it.

Considering the other side, Aristotle's own arguments for the finiteness of space achieve even less. Firstly, for the most part, he directs his attacks against an infinitely extended body, and only a fraction of these arguments can be applied to infinite space. As I have mentioned, the reason for this lies in the fact that Aristotle has already rejected the possibility of empty space elsewhere, and hence he argues against an infinite plenum (or body). Therefore, in this way, Aristotle`s rejection of void has a traceable effect on his reasoning against the infiniteness of the universe. In essence, this is the nature of the connection between the arguments of different chapters, which I referred to in the Introduction.[198] After all, through the concept of void (or through its rejection) the arguments concerning two separate questions (the current one and the one concerning void) are connected. There is yet another similar connection present between chapters III and IV, which I will talk about in the next chapter. For now, let us return to the discussion of the problems concerning Aristotle's arguments against the infiniteness of space.

Interestingly, it is Aristotle's misconception that "infinite bodies are infinitely extended in all directions", which, occasionally, enables us to relate his arguments to infinite space. After all, when describing infinite space, we also imagine a vast emptiness infinite in all directions. The reason why Aristotle's focus is on infinite bodies is that he rejects the possibility of void (for him, only plenum can fill space),

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[197] As I have said, in this thesis, I intend neither to refute nor to corroborate arguments using current speculations on the abstract nature of space. For my reasons, see: pg 34-5.

[198] See: chapter I, pg 9.

which he presupposes throughout his arguments. Therefore, his conclusions are valid (providing that the argument itself lacks logical mistakes), in so far as we agree with him on the impossibility of void. Consequently, in Aristotle's view, the only possible way in which space can be unlimited is if body is also infinite. However, the Atomists never argue for the existence of such a single unlimited mass, and believed in the existence of empty space.[199]

Secondly, for the most part, Aristotle bases his arguments on his own assumptions, concerning natural motion (and rest) or the behaviour of the four elements. In general, these assumptions should not be taken for granted,[200] and ascertaining their truth-value requires a detailed analysis of the arguments with which they were originally defended. Consequently, Aristotle's conclusions (based on such assumptions) should not be accepted without reservations. Against the Atomists, such arguments do not work either, since they argue from different principles than Aristotle.[201] Consequently, in my opinion, Aristotle's arguments fail to prove the finiteness of space. To sum up, although neither side manages to prove their case without qualifications, the arguments for the infiniteness of space achieve more success than Aristotle's counter-arguments.

[199] I will investigate the question on void in a separate chapter.

[200] For instance, we know that Aristotle's theory, concerning the elements, is not valid. This fact renders the vast majority of the arguments expounded in *De Caelo* (book I.5-7), which are ultimately based on the behaviour of the elements, invalid. For the relevant part of my analysis, see: pg 60-70.

[201] For instance, the behaviour of the atoms is essentially different from that of the Aristotelian elements. For the other differences, consult my analysis of the relevant chapters.

Chapter III

Is There Such a Thing as "Empty Space"?

In the present chapter, I will consider the question of empty space (or void), with respect to which the Atomists and Aristotle adopted opposite views. The latter denied its existence, and mounted several attacks against those (Atomists included), who admitted "vacuous space" into their system. The majority of Aristotle's arguments are summed up in his *Physics* (book IV.6-9). When dealing with Aristotle's counter-arguments, this text will serve as my principal focus in my analysis. At the same time, I will refer to other passages whenever it is relevant. In the *Physics*, Aristotle regards "void" (τὸ κενὸν) as "vacant space, which is capable of being filled by body", in which case, it persists as the object's place. This is the sense of void, which he spends the most time arguing against.[202]

However, it is uncertain whether the Atomists understood void in this "receptive" sense. The pertaining scholarly discussion is complex, with several parallel interpretations being proposed. Basically, with respect to the void of the early Atomists, there are two main alternatives. Sedley nicely expounds the difference between them.[203] On the one hand, there is the "receptive" sense attacked by Aristotle (1,). On the other hand, it is argued that Democritus' void was "non-receptive" (unable to receive atoms) (2,). In this view, it is more like a "negative element" or "not-being" (τὸ μὴ ὄν), the opposite of the atom, which is "being" (τὸ ὂν).[204] This kind of void cannot be filled by atoms, but rather "surrounds" them like an imperceptible medium, and "yields" to their motion. To evaluate Aristotle's refutation adequately, it is essential to ascertain in which of the above senses Democritus and Leucippus understood void. After all, if their void was strictly (in all

[202] 213a15-9; Solmsen, 1977, pg 265; Hussey, 1983, pg 122-3; I will return to this question in my analysis.
[203] Sedley, 1982, pg 175-6.
[204] Aristotle, *Metaphysics*, 985b5-7.

instances) non-receptive (2,), Aristotle's arguments in the *Physics*, by virtue of taking (1,) as their premise, lose much of their value, and cannot be regarded as a direct refutation of the actual Atomists' view.

Furthermore, the question whether, with respect to the early Atomists (principally, Democritus and Leucippus) and the Epicureans, empty space meant the same, or denoted different entities, is also open to debate. Therefore, as an introduction, I will attempt to define what Democritus and Leucippus understood under the concept of void. This, in turn, will reveal whether Aristotle is rightly attributing the "receptive" kind of void to the Atomists or not. As my analysis will reveal, his interpretation was not altogether objectionable, because, in most probability, the void of the early Atomists was indeed receptive (1,). In addition, still as part of the introduction, I will ascertain the difference (if there is any) between this "earlier" meaning of void and that of Epicurus and Lucretius. Here, I will argue for a view which regards Epicurus's void as more or less similar to that of Democritus and Leucippus (I regard both types as receptive, empty space (1,)). Then, in the main section, I will consider the arguments for and against the existence of empty space in a similar manner as I did in the previous chapter on the "extension of space". Finally, I will conclude that, based on these arguments, the existence of void is neither proven nor disproven. Nonetheless, as we shall see, the Epicureans achieve a "partial" success in proving their case, whereas Aristotle's attempt to refute the existence of empty space is entirely unsuccessful. However, prior to the actual analysis, let us discuss what τὸ κενὸν meant for the Atomists.

III.1 The early Atomists' concept of void

Let us proceed chronologically, and discuss Leucippus and Democritus first. As I have said, at the beginning of his principal attack on the existence of void (*Physics*, book IV.6-9), Aristotle attributes the "receptive" void concept (1,) to the Atomists, and argues against this specific notion afterwards:

"For those who say there is void suppose it to be a kind of place and a vessel; it is thought to be a plenum when it contains the extended body it is capable of receiving, and void when deprived [of that body],"[205]

Here, τὸ κενὸν is referred to as δεκτικός, which is something "capable of receiving something else" (in this case, an object). A bit further down (213a28-9), this specific sense of void is reaffirmed by being called an "extension" (διάστημα) in which there is no body perceptible by sense. This passage closely follows 213a15-8, and, by virtue of this proximity, the capability of this "empty interval" to receive bodies should be understood implicitly. Simplicius adopted Aristotle's view, and identified Democritus' void in a similar manner:

"This interval is said by the school of Democritus and Epicurus to be void, so as sometimes to be filled by body and sometimes to be left empty;"[206]

Here, the same "section of space" (or "interval" indicated by the word διάστημα) can be full at one time and empty at another time. Simplicius' "temporal distinction" (ποτὲ… ποτὲ…) nicely illustrates the receptive nature of void, which is presently empty, but can be filled at any time. With respect to this receptive usage of τὸ κενὸν, two types can be distinguished. In its broader sense (1,a), τὸ κενὸν refers to both empty and occupied space, which suggests that, in early Atomism, there was no clear distinction between void and space.[207] Simplicius writes that, it can be "full at one time, and empty at another time", and, in Aristotle, it has both occupied and unoccupied parts. In its narrower (or stricter) sense (1,b), τὸ κενὸν denotes only the presently empty parts of space. For instance, at one place, void is called by Simplicius "place deprived of body" (τόπον ἐστερημένον σώματος),[208] a phrasing which resembles that of Aristotle in the *Physics* (213a28-9), and clearly refers to empty space only. Since, even in its stricter sense, void can be seen as "potentially" occupied space, the only difference between (1,a), and (1,b), is whether we continue referring to the same thing as τὸ κενὸν, even after it gets filled. Numerous arguments describe

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205 *Physics*, 213a15-18.
206 Simplicius, *On Aristotle Physics*, 571, 27-9.
207 Guthrie, 1965, pg 391 (note 3); The broader usage is implied by the above passages (see: notes 205 and 206).
208 Simplicius, *On Aristotle Physics*, 397, 4.

processes, when a previously void interval (X) gets filled (or conversely),[209] while X itself subsists as the object's place, and often goes on being referred to as τὸ κενὸν (even in its occupied state). Therefore, postulating the concept in its broader sense (1,a) facilitates understanding. Nonetheless, in my analysis, I will refrain from distinguishing (1,a), and (1,b), and simply regard the receptive void as "empty space, which can accommodate bodies", and, in its occupied state, is not destroyed, but persists as the object's place. Furthermore, both Aristotle's and Simplicius' passages regularly refer to void as "place" (τόπος) or "interval" (διάστημα), which further indicates its function as a "spatial entity", a kind of space.[210] Simplicius was an expositor of Aristotle, and it is hardly surprising that he shared Aristotle's view that Democritus' void was "receptive".

There are numerous passages (including the accounts of Aristotle and Simplicius), where some kind of motion is said to occur in (or into) the void. In order to be considered plausible interpretations, both the "receptive" (1,) and "surrounding" (2,) void concepts need to be compatible with those expressions within the passages, which refer to such movements. In Diogenes Laertius we find that, according to Leucippus, at the commencement of a world's formation, the atoms are said to be "falling into" (εἰς τὸ κενόν ἐμπιπτόντα) or "carried into" (φέρεσθαι εἰς κενόν) the void.[211] These are passages where bodies (for instance, the atoms) enter or move **into** the void.

In addition, there are several instances, where some kind of motion is said to occur **in** the void. For instance, Aristotle says (*De Caelo*, 300b9-10) that the "primary bodies (of Democritus and Leucippus) are always in motion within the void" (ἀεὶ κινεῖσθαι τὰ πρῶτα σώματα ἐν τῷ κενῷ). In Simplicius, the atoms are described as "being carried in the void" (φέρεσθαι ἐν τῷ κενῷ).[212] Cicero writes that the atoms "travel in

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[209] For instance, the "emptying of a vessel" (Aristotle, *Physics*, 211b14-29), or "the placing of an object into the void" (*ibid*., 216a26-b16).

[210] Some examples where τὸ κενὸν is referred to as τόπος are: Aristotle, *Physics*, 208b25-7, 213a15-8; Simplicius, *On Aristotle Physics*, 395, 1, 533, 17-8. There are other passages which identify void with a kind of place. Since these latter ones deal with Epicurus, I will consider them in my discussion of the Epicurean concept of void.

[211] Diogenes Laertius, ix.30-1.

[212] Simplicius, *On the Heavens*, 295, 10.

infinite void" (*censet in infinito inani*), and Eusebius also writes about atoms "being carried in the void" (ἐν τῷ κενῷ φερομένας).[213] As I see it, the act of going **into** (or being **in**) a place entails the actual "filling" of that place. In the above instances, the atoms enter and fill the void, which must be capable of accommodating the atoms. This ability belongs to the "receptive" kind of void (1,), and not the "surrounding" type (2,). Therefore, these passages imply that τὸ κενὸν of the early Atomists was receptive and not surrounding.

The proponents of the surrounding interpretation might argue that the fact that "motion occurs in (or into) the void" is also compatible with the surrounding (2,) view, since, in the latter case, τὸ κενὸν can surround and yield to the moving object in the same way as water surrounds and gives way to the moving boat. Since we use such expressions as "falling into" or "moving in" water, we might also use them in connexion with the surrounding type of void (2,) in which movement can be conceived in a similar way. However, I have two objections against the idea of relying on this "water analogy" to explain how the Atomists imagined motion in the type (2,) void. Firstly, if the early Atomists (or those referring to them) indeed thought of "motion in void" as "movement in water", it seems strange that none of them came up with the "water analogy" (or at least, not in the extant passages). After all, if I imagine τὸ κενὸν as some kind of imperceptible water, it feels natural to explain myself with the following analogy: "atoms travel in the void, just as fish swim in the sea". Therefore, it seems more plausible that, in the eyes of Democritus and Leucippus, void was not some kind of surrounding material, but empty space, in which objects can move. Secondly, both imagined as some kind of water and in general, the surrounding kind of void (2,) necessarily possesses the ability of motion (must be capable of being replaced by the traveling atoms). However, I find it hard to believe that the Atomists, being so consistent in depriving the void of all qualities belonging to the atoms (and regarding it as the polar opposite of corporeal objects), would have still attributed the ability of motion (peculiar to the world of atoms) to nethe void. After all, it feels unusual to assign motion to something completely incorporeal. One might ask Sedley, in the case of the void's motion, what it is that

[213] See: under Democritus in Diels-Kranz (DK 68 A 56, and 43 respectively).

moves. How can this moving "nothingness" be imagined?[214] Based on these considerations, the "water analogy" cannot be used to explain how objects might move in the "surrounding" type (2,) void.

Having rejected the "water analogy" as a potential reason supporting the "non-receptivity" of void, let us consider some additional arguments, which also endorse the "surrounding" view. Some scholars argue that the notion of "the Atomists' void being empty space, which is capable of accommodating bodies" (1,) originates from Aristotle, who invented it for the sake of his argument in the *Physics*.[215] They hold that Democritus and Leucippus did not look at void in this way.[216] Some, like Solmsen and Hussey, simply deny the "empty space" identification without providing an alternative interpretation. Sedley, in contrast, comes up with a theory which is similar to that of (2,).[217] In his view, it is only in Epicurus, where void becomes regarded as (1,). Earlier (before Aristotle), τὸ κενὸν of the Atomists was not the same as empty space, but an entity, lacking any tangible qualities, yet occupying space alongside atoms. Why should we regard the void as some kind of "negative" element, the opposite of atoms, which fills space, and is capable of locomotion?

One of the reasons Sedley adduces derives from those passages, where void is called "not-being" (τὸ μὴ ὄν) or "nothing" (τὸ μηδέν), whereas the atoms are called "being" (τὸ ὂν) or "thing" (τὸ δὲν) respectively.[218] According to Sedley, the "dualistic" designations of ὂν and μὴ ὄν assign void to the same category as the atoms. Hence, it becomes a kind of intangible element, the opposite of atoms. From this, it follows that τὸ κενὸν is no longer empty space, but something occupying space. This type of void is also capable of locomotion. This attribute is necessary in order not to hinder

[214] This objection can be applied against the surrounding void concept in general, and not just in reference to the above "water analogy".
[215]. In the Physics, Aristotle identifies void as "empty spatial-extension", and goes on to refute it in this specific sense.
[216] Sedley, 1982, pg 179; Solmsen, 1960, pg 140-1; in his commentary of the pertaining passages, Hussey also expresses his doubts whether τὸ κενόν of the Atomists was indeed receptive or not. However, he does not go as far as endorsing the "non-receptive" view (Hussey, 1983, pg 123, 126-7). In contrast, Algra argues that Aristotle's receptive interpretation of Democritus's void is largely correct (Algra, 1995, pg 46-50). As I will demonstrate in the following, I endorse this latter view.
[217] Sedley, 1982, pg 175-6.
[218] For instance: Aristotle, *Metaphysics*, 985b5-7; Simplicius, *On the Heavens*, 295, 4-6, *On Aristotle Physics*, 28, 13-7. For more references, see: under Democritus in Diels-Kranz (DK A 38, 40, 44, 45, 49).

"the free motion of atoms", which is an essential tenet of Atomism.[219] So, by virtue of dispensing with "receptivity", Sedley needs his "void particles" to be capable of being displaced by the incessantly moving atoms, while offering no resistance. In addition, Sedley argues that the designation of void as μὴ ὄν or μηδέν is incompatible with the receptive void concept (1,), yet compatible with his view (2,). [220] However, as I see it, there is no such difference between (1,) and (2,).

In order to provide an explanation, let us see how void as "non-existent" (μὴ ὄν) can exist. On first look, to say that the "non-existent" exists seems to be an apparent contradiction, and to resolve it we must look at the reasons why the early Atomists referred to void as "nothing".[221] For this, we must go at least as far back as Parmenides. In his "Way of Truth", Parmenides argues that only "what is" (ὡς εστίν) exists, and "what is not" (ὡς οὐκ εστίν) has no part in our universe, which is finite, and consists of a homogenous substance (the "what is"). The latter is changeless and continuous, filling all available space, and leaving no parts of it empty. Melissus elaborates Parmenides' argument, and shows how the impossibility of empty space precludes locomotion.[222] If "emptiness" (τὸ κενὸν) existed, it (or "being") "could give way into the emptiness" (ὑπεχώρει ἂν εἰς τὸ κενόν). However, τὸ κενὸν is equated with "nothingness" (μηδέν), which takes no part of reality (Parmenides's principle). Therefore, the void does not exist either. Since there is nothing to "give way into" (or "to retreat into"), locomotion is not possible. By virtue of the ability of Sedley's "void particles" to "be displaced" by matter with zero resistance, both kinds of void (1, and 2,) seem to fit into Melissus' argument. In other words, both enable movement. However, as Aristotle points out (*Physics*, 214a28-30), even the particles of regular matter can "make way for each other" (ὑπεξιέναι ἀλλήλοις). Therefore, if Aristotle

[219] By virtue of being a "space-occupier" existing alongside atoms, τὸ κενὸν (of this type) is no longer receptive (otherwise, if an atom were to enter a place where there is already a "void particle", two distinct spatial entities would coincide, a possibility, to which Democritus would have undoubtedly objected).
[220] Sedley, 1982, pg 179.
[221] It is only in early Atomism where void can be called μὴ ὄν or μηδέν. Epicurus no longer used these designations.
[222] Melissus 30 B 7 in Diels-Kranz.

is correct in saying this, the presence of void (either kind) becomes redundant in explaining motion.[223]

Nonetheless, there are reasons which suggest that the receptive void is more suitable for Melissus' argument. Firstly, the phrase that something "retreats **into** the void" (ὑπεχώρει εἰς τὸ κενόν) implies the accessing and filling of a vacant place, an action which can be easily accounted for by the receptive interpretation (1,) of τὸ κενὸν. As we have seen, by appealing to the notion of how objects move in water (the so called "water analogy"), it is possible to explain the above action even if void is regarded as surrounding and non-receptive (2,). However, we have also seen that using the "water analogy" in connexion with τὸ κενὸν is highly problematic.[224]

My second reason originates from Melissus' distinction between being πλήρης and οὐ πλήρης:

"If something "yields" (χωρεῖ) or "receives into itself" (εἰσδέχεται), it is "not full" (οὐ πλήρης). If it neither yields nor receives, it is "full" (πλήρης)."[225]

It follows that only those things can "yield to" (χωρέω) objects or "receive" (εἰςδέχομαι) them which are "not full" (οὐ πλήρης). Although the word πλήρης can also denote atoms, its conventional meaning is "to be full". In this sense, something is full which contains no empty sections within itself. I think Melissus specifically chooses the expression οὐ πλήρης here owing to its conventional meaning. Accordingly, the reason why things, which can "yield" or "receive", are called οὐ πλήρης is the following: since they are not (completely) full, they have empty sections within. It is by virtue of these empty sections that they can "receive" other objects, since the latter can actually enter into or pass through these void gaps. I am talking about pockets of space, which are empty in a "strict sense", like the vacuum of modern physics. This kind of empty space is not identical with the non-receptive

[223] I will consider the question "whether void is necessary for movement or not" in greater detail later on.

[224] For the reasons, see: pg 78-9. My interpretation of Melissus' passage is shared by Algra, who also rejects the notion of a non-receptive void, on the grounds that the presence of such phrases as "to retreat **into** the void" (ὑπεχώρει εἰς τὸ κενόν) implies that Melissus regarded τὸ κενὸν as something which can be filled (Algra, 1995, pg 42-3).

[225] Melissus 30 B 7 in Diels-Kranz (my own translation).

type of void (2,), which surrounds matter, but without being "vacuous".[226] In other words, assuming the conventional meaning, something is οὐ πλήρης, which contains sections of space, which are "actually" empty (for instance, the receptive kind of void (1,)). Furthermore, it is by virtue of these empty sections that something οὐ πλήρης can "yield to" objects or "receive" them.

In the main argument (see: page 80), it is stated that motion is impossible, since everything is "full" (πλήρης), so there is nothing which could "yield" or "receive" objects. Melissus argues that this is so, because τὸ κενὸν, which renders something οὐ πλήρης, does not exist. Therefore, assuming the conventional meaning of the word πλήρης, τὸ κενὸν becomes identical with the above described empty intervals by virtue of which something is "not full". As we have said, these are three-dimensionally extended empty (or vacuous) intervals, which might be equated with the receptive type of void (1,), but not with the surrounding kind (2,). In other words, if we assume that, in the last four lines of B 7, Melissus uses the word πλήρης in its conventional sense, the receptive void concept (1,) turns out to be more suited to describe the meaning of τὸ κενὸν used by the argument than the non-receptive (2,). This suggests that, here, Melissus might be thinking of the receptive kind of void, and not the non-receptive.

Leucippus and his follower Democritus adopted Melissus' designation of void as μὴ ὄν or μηδέν, but maintained that, despite being "nothing", it still existed. It seems reasonable to assume that, besides these designations, they also adopted the kind of void concept which Melissus is refuting. Since, as we have seen above, the receptive void (1,) appears to be the more likely target of Melissus, the early Atomists must have regarded their void in this sense as well. Therefore, these considerations yield the opposite conclusions than those of Sedley, who maintains that the "dualism" (the "being" and "non-being") of Parmenides and Melissus entailed that, as the Atomists replied to the Eleatic arguments, they necessarily regarded void as an element, non-receptive, and capable of locomotion (2,).[227] After all, there is no reference to τὸ

[226] The type (2,) void is strictly non-receptive. Therefore, it is not identical with "regular" empty space, which could be occupied by plenum. Rather, it is more like an imperceptible medium, which merely surrounds matter (see: page 74).
[227] Sedley, 1982, pg 177.

κενὸν in Parmenides' poem, while Melissus equates it with μηδέν, and denies its existence. In addition, the claim of the "dualistic" view that "τὸ κενὸν is the polar opposite of the atoms, in so far as being entirely "characterless" and imperceptible",[228] and the claim that "atoms move into the void, after which, the latter ceases to be empty, and no longer called void (this is what (2,) entails)" do not seem to be mutually exclusive. Consequently, as I see it, the Eleatic heritage does not preclude the receptive void, and Melissus' argument downright necessitates it.

So, what was the exact nature of Democritus' and Leucippus' void? As we have seen, Aristotle's Physics clearly regards τὸ κενὸν as "empty space, capable of being filled" (1,), and, I believe that it is probable that he was right (or at least, there is no conclusive evidence to doubt his interpretation).[229] Furthermore, I endorse Inwood's suggestion that the principal reason why void is referred to as μὴ ὄν (or μηδέν) in some of the passages is the fact that these designations are rather intended as a reply against Melissus' argument than conveying a general idea on the nature of void.[230] Consequently, μὴ ὄν and μηδέν are specifically and not generally applied designations. Epicurus, being further away in time, was no longer concerned with refuting the Eleatics. Therefore, Epicurus dispensed with μὴ ὄν and μηδέν, but retained κενὸν as a designation, a fact which might suggest that, for his predecessors, κενὸν was the only universally applicable predicate of void. In other words, the only thing Democritus and Leucippus could universally predicate of void was that it was "empty".

I have an additional objection against the non-receptive, surrounding void concept (2,). Namely, why is it that, if, as Sedley says, the "void-particles" are capable of motion, no ancient source actually mentions this fact? Τὸ κενὸν is never said to move, whereas the atoms are quite frequently referred to as moving in the void.[231] If both the atoms and the void were thought of as "elements capable of motion", we

[228] See: Sedley, 1982, pg 177-9.
[229] Inwood, and Algra also suggest that, in the *Physics*, Aristotle is reasonably just in presenting the Atomists' concept of void (Algra, 1995, pg 48-9; Inwood, 1981, pg 273).
[230] *ibid*., pg 273.
[231] For instance: Aristotle, *De Generatione et Corruptione*, 325a31-2; Simplicius, *On the Heavens*, 295, 10, *On Aristotle Physics*, 1318.33-19, 4.

should expect a more or less equal amount of references to the movement of both. Yet, only the atoms are referred to in this way, and the void never.

All in all, it seems more plausible that the early Atomists understood τὸ κενὸν as "empty space, capable of being filled" (1,), and not as "some kind of 'non-being' surrounding the atoms" (2,). Even if one doubts Aristotle and Simplicius, who explicitly declare void to be (1,), there is still no reason to regard void as Sedley does (2,).[232] Although, based on the available evidence, we cannot ascertain the exact nature of Democritus' and Leucippus' void, as we have seen above, there are several reasons suggesting the receptive view, and none implying the surrounding interpretation. Therefore, in my opinion, based on the evidence, one should either refrain from choosing between (1,) and (2,), or opt for the more likely candidate which is the receptive interpretation (I favour this latter alternative). In other words, I am also not entirely convinced that the early Atomists' void was receptive, and I only consider it likely. Nonetheless, for the sake of simplicity, in my analysis, I will accept Aristotle's receptive interpretation, and assume void to be "empty space, capable of receiving objects" (1,).

III.2 The Epicurean void

After discussing the early Atomists, let us turn to Epicurus (and Lucretius), and ascertain the difference (if there is any) between their void concept and that of Democritus and Leucippus. In Epicurus' case, the candidates proposed for void are essentially the same as those considered in connexion with Democritus. Although there are certain differences in the details, one interpretation regards Epicurus' void as "surrounding (non-receptive) medium, capable of being displaced" (this one resembles (2,), so I will keep referring to it in this way). The alternative view endorses

[232] This seems to be the opinion of some modern scholars (Furley, 1987, pg 191 (note 14); Taylor, 1999, pg 185-6). In their view, Democritus' and Leucippus' notion of space was not sophisticated (or straightforward) enough to decide whether their void was receptive or surrounding. In addition, Furley also adds that Sedley's interpretation of void is ungrounded.

the "receptive, empty space" type of interpretation (resembling (1,)).[233] In deference to their similarity, I will retain the same numbering when referring to them. Looking at the theories of Inwood and Sedley, one can easily apprehend the controversial nature of the matter. As we have seen in the previous section, Sedley regards Democritus' void as surrounding (2,). However, in order to maintain a distinction between Epicurus and Democritus, he holds Epicurus' void to be receptive (1,). In contrast, Inwood postulates the exact opposite. In his view, it is Democritus, whose void was receptive, whereas the surrounding interpretation is attributed to Epicurus (and Leucippus).[234] For my part, I propose that there was less difference in this respect between the early Atomists and Epicurus than these authors assume. It must be stressed that, although they are essentially the same, certain differences between the two void concepts still apply. For instance, Epicurus used a different set of predicates for the void than the early Atomists (see: further down).

In the following, I will attempt to show that, just like the early Atomists, Epicurus also regarded void as receptive empty space. Firstly, I will endeavour to refute the arguments in favour of the surrounding interpretation, and then, I will adduce some additional arguments supporting the receptive view. Inwood, in his argument for a surrounding (2,) void, adduces several reasons why Epicurus' void could not be receptive. According to Inwood, if void were receptive, it would violate the strict "division" (διαίρεσις) between atoms and void. Epicurus, following his predecessors, made up his universe from two distinct entities: the atoms and the void.[235] Dionysius the Thracian (see: Usener 92) writes that Epicurus "divided the whole into atoms and void" (διαιρῶν τὸ πᾶν εἴς τε ἄτομον καὶ κενόν). As Inwood points out, this division suggests that the atoms and the void are two distinct entities, which requires a void concept, sufficiently distinguishable from the atoms. According to Inwood, only the

[233] For my original description of (1,) and (2,) types of void, see: pg 74-5.

[234] With respect to Epicurus' void, most scholars favour the receptive interpretation. Both the discussion of Bailey and that of Rist reflect the receptive view. Sorabji also explicitly rejects Inwood's surrounding interpretation (Bailey, 1928, pg 294-6; Rist, 1972, 56-7; Sorabji, 1988, pg 76-8).

[235] In Diogenes Laertius (x.39) it is stated that "the whole consists of bodies and void" (πᾶν ἐστι σώματα καὶ κενόν). In fact, "σώματα καὶ κενόν" forms a supplement to the text, which is accepted by most scholars (see: Inwood, 1981, pg 276; Sedley, 1982, pg 183; Rist, 1972, pg 42). Lucretius (*De Rerum Natura*, 1.419-20) used the same division of reality into "bodies" (*corpora*) and "void" (*inane*). For more references, see: Diog. L, x.40. 86; Usener 74-6.

“surrounding” void can fill this requirement. In addition, he claims that Epicurus’ division is “fundamental”. What this means is that Epicurus regarded the atoms and void as contraries in the form of “*A* and *notA*”.[236]

Obviously, those designations (both concerning the early Atomists and Epicurus), which simply call the atoms σώματα (or ἄτομον), and void κενόν, were not intending to exhibit the fundamental opposition between atoms and void.[237] As has been said, Epicurus dispensed with the “ὂν” and “μὴ ὄν” designations, which could have provided the fundamental opposition. Unlike the “ὂν and μὴ ὄν” (“being” and “not being”), where an opposition (in the form of “*A* and *notA*”) is apparent, in the case of Epicurus’ designations of atoms and void, the opposition is not so apparent. Still, there is a pair of predicates (the tangible and intangible), which could fill this role.

Epicurus referred to void as “intangible nature” (ἀναφής φύσις), emphasizing its incorporeality, and imperceptibility. Usener 92 distinguishes atoms and void by calling the former στερεὸν and the latter φύσις ἀναφής. However, since στερεὸν means “solid” and not “tangible”, the opposition is still not as perfect as the “being and non-being” of the early Atomists. Lucretius (*De Rerum Natura*, 1.430-9) seemed to be more exact in this respect, since he called the atoms *tactus* (tangible) and void *intactus* (intangible), which made the opposition compatible with the form of “*A* and *notA*”.[238]

For Inwood, the fact that “atoms and void are strict contraries (in the form of ‘*A* and *notA*’)” excludes the receptivity of void. However, he omits to explain the reasons underlying his conclusion, and seems to simply take for granted the notion that “strict contraries cannot occupy the same place” (hence, the ban on the receptive void). However, I do not see why, in the case of the atoms and void, such a notion should apply. For me, it seems perfectly credible that void (as “intangible nature”) has the potency to receive tangible entities (bodies), while remaining their strict opposite. After all, strictly speaking, it is not the void, which, after being filled, becomes

[236] Inwood, 1981, pg 277.
[237] Concerning Epicurus, see: Diog. L., x.39, Usener 74-5. With respect to Democritus, see: Diog. L., ix.44.
[238] For a more detailed argument on this issue, see: Inwood, 1981, pg 276-8; Sedley, 1982, pg 189-90.

tangible, but the object itself which possesses this "quality". Therefore, unlike Inwood, I do not reject Sextus Empiricus' evidence, which states that the ἀναφής φύσις can be occupied, in which case, it is no longer referred to as κενόν, but called place (τόπος).[239]

In addition, it is possible to interpret the opposition between being tangible and intangible in a way which does not require void to be incapable of receiving objects. For instance, there is Sedley's possible interpretation of the predicates "tangible" and "intangible", which allows void to receive bodies.[240] According to his interpretation, both predicates denote extensions. The difference lies in the fact that, if something *tactus* is added to an existing body, it will increase its quantity, whereas the addition of an intangible entity won't increase the quantity. Understanding the contrast between tangible and intangible in this sense does not depend on the receptivity of void in any way, since the essence of the difference (between being tangible and intangible) lies in the ability to increase (or to not increase) an object's quantity. In conclusion, the fact that the atoms and void are contraries does not exclude the receptivity of the latter.

In addition, Inwood argues that Epicurus must have based his concept of void on some empirical observation. In Epicurus' system, a "general concept" (πρόληψις) of some existing thing is derived from the correct "recognition" (κατάληψις) of repeated sense experience of a particular occurrence in nature.[241] According to Inwood, in the case of void, Epicurus observed how fluids (for instance, water) surrounded (and gave way to) objects, and based his void concept on these observations. In other words, his void surrounded and yielded to objects, just as water did (irrespective of the resistance).[242] However, I do not see how this theory can be justified. Firstly, we have no extant evidence, which attests that Epicurus used the "water analogy" in this way. The Lucretian passage Inwood cites to corroborate

[239] Sextus Empiricus, *adversus mathematicos*, x.2.
[240] Sedley, 1982, 189-90; this interpretation relies on a passage from Lucretius (*De Rerum Natura*, 1.430-9), where void is referred to as *intactus* and the atom as *tactus*.
[241] *ibid*., x.33; For more on what "general concepts" are and how they are derived, see: Rist, 1972, pg 26-30.
[242] Inwood, 1981, pg 278-9.

his theory, cannot serve as evidence.[243] Here, Lucretius indeed describes “motion in water”, but not in order to expound the nature of void. Rather, the presence of void is used to explain how fish can swim in the water: water can yield, because the moving animals leave behind empty space (void), into which the water flows. Therefore, there is no evidence to support Inwood’s idea that Epicurus based his void concept on how fluids yield to moving objects.

Inwood also argues that Epicurus made his void like a “surrounding medium” in order to avoid Aristotle’s criticism that “if void were able to receive bodies, it would lead to two distinct entities being in the same place” (*Physics*, 211b14-29, 216a26-b16).[244] By making void able to yield, Epicurus could maintain a spatial separation between the atoms and void, and escape Aristotle’s criticism. The first passage in which Aristotle expounds this criticism (211b14-29) is, in fact, rather obscure. Strictly speaking, Aristotle does not argue against void in this passage, but against “place” (τόπος) as “extension, which exists independently of body” (διάστημα, ὡς ὄν τι παρὰ τὸ σῶμα).[245] In other words, an object’s place would be something independent, which would subsist even when left behind. According to Aristotle, this would have the result that “an infinite number of such places coincide” (211b20-21).

His first example (211b21-3) describes the process of “replacement” (ἀντιμετάστασις), where the displaced parts of water leave behind their places, which results in an infinite number of partly coinciding places within the container. Aristotle’s second example (211b23-5) describes the case where the place itself “moves” (μεταβάλλει) in the course of which, it occupies other places.[246] As a result, many places coincide. These arguments can be refuted, and I find it hard to believe

[243] Lucretius, *De Rerum Natura*, 1.370-84.
[244] Inwood, 1981, pg 280.
[245] Ross’ version of the text contains another reference relating to the self-subsidence of the extension (211b19-20). Here, Ross supplemented the text as follows: διάστημα <καθ’αὑ> τὸ πεφυκὸς <εἶναι>. Simplicius’ version of the text is without the “καθ’αὑ…εἶναι”. Although Ross emendation does not alter the sense of the argument, it is not absolutely necessary. Even without the “exists by itself” part, it is evident that Aristotle argues against an extension which exists separately of the occupying body (211b17). Such an extension is indeed can be said to exist “by itself” (καθ’ αὑτὸ). For more on this emendation of the text see: Morison, 2002, pg 124 and note 84; Ross, 1936, pg 572.
[246] Although it is not explicitly stated, the example probably refers to the space inside of a moving container, which being dependant on the container, is also in motion, during which, it occupies other places (see: Ross, 1936, pg 573).

that Epicurus, having been convinced by them, would have modified his theory of void. For instance, Epicurus could have replied that, during replacement, the places occupied by the remaining portions of water do not exist separately from each other. Rather, it is only the place of the "whole" water, which subsists, and becomes less and less occupied by water, after which it either remains empty (void), or gets filled by some other body. Since the places occupied by the remaining parts do not exist separately, the process of replacement does not produce overlapping places. Even if one were to assume that the places of the emptied portions subsist, as Philoponus shows, the overlapping of such empty extensions would entail no impossibility.[247] It is only bodies, by virtue of being material, which cannot occupy the same place. In contrast, void is immaterial, and, at least in theory, the overlapping of such extensions is possible.

With respect to the moving container, looking at place (or void) as Epicurus did, it is not that the place within the container, in the course of its movement, acquires "other places for its own location" (τοῦ τόπου τ᾽ ἄλλος τόπος). Instead, it is only the container, which is in motion (and not its place), and which occupies successive portions within the whole void, while the latter remains static, and identical. Therefore, there is no concurrence of places. I believe this is what the passage in Diogenes Laertius implies, when describing the Epicurean void as something, "through which" (δι᾽ οὗ) bodies move.[248]

The other passage (216a26-b16) seems to be more convincing. Here, Aristotle argues that if we put a cube into empty space, it will penetrate (become concurrent with) a part of void equal to the cube's volume (216a34-5). This originates from the fact that, in Aristotle's system, only bodies can "displace" (ἐξίστημι) each other, and void is no body. Hence, a part of void will penetrate, and coincide with the cube. If we deprive

[247] Philoponus argues that since void, unlike material objects, is immaterial, in theory, the superimposition of void spaces is not impossible. Just as with other kinds of immaterial extensions (lines and surfaces), their lack of materiality enables them to overlap (Philoponus, *On Aristotle Physics*, 560, 20-61, 5).

[248] Diog. L., x.40; Philoponus also regards void as immovable, and says that the moving vessel does not carry its place around (the space within it). Instead, it occupies new places during its movement (*On Aristotle Physics*, 562, 1-11).

the cube of all its properties (such as, its constituent matter, or colour),[249] it won't be possible to distinguish the resulting "pure" extension from the coincident part of void (216b7-10). Consequently, void is either identical to the body's extension, or indistinguishable from it. In either case, its existence is superfluous in describing reality.[250] As I see it, Epicurus could have maintained the receptivity of void, even if he accepted Aristotle's conclusion that "when being filled, void cannot be differentiated from the extension of the occupying body". After all, since the ἀναφής φύσις lacks material attributes, it is indeed indistinguishable from "pure" extension. Even so, empty space does exist separately, since it subsists after being left behind by the constantly moving atoms.

Furthermore, the argument (216a26-b16) cannot testify to Inwood's "fluid-like" void either, since it clearly presupposes that "only bodies can be displaced, and void, not being a body, cannot" (a29-34). Inwood argues that Epicurus might have disregarded Aristotle's restriction, and made his void able to yield, since he formulated his concept, based on how "fluids yield to the moving objects".[251] However, as I have already demonstrated above, there is no evidence to support the idea that Epicurus regarded void as some kind of intangible fluid. In addition, the fact still remains that, strictly speaking, Aristotle's argument does not allow void to be like a surrounding medium. What is more, as Sedley indicates, there is ancient evidence, which suggests that even Epicurus himself objected to the idea of a yielding void.[252] In Diogenes Laertius (x.67), it is stated that the void "can neither act nor suffer action" (οὔτε ποιῆσαι οὔτε παθεῖν δύναται). It follows that it cannot be displaced either.

Inwood interprets some passages (Diog. L., x.44, 46, 61) as evidence for the void's ability "to be displaced by the moving atoms".[253] These passages refer to the void's inability to "resist" (ἀντικόπτειν) the motion of the atoms. However, the statement that "the moving atoms meet no resistance in the void" is not the same as saying that "the void is displaced by the moving atoms". Furthermore, the ability to offer no

[249] This is only possible in theory, since, in Aristotle's system, the "properties" (πάθηματα) of a body are "not separable" (μή χωριστόν). In other words, they cannot exist independently of the object.
[250] Hussey, 1983, pg 133.
[251] Inwood, 1981, pg 282.
[252] Sedley, 1982, pg 187.
[253] Inwood, 1981, pg 277-9.

resistance is also compatible with receptivity. After all, supposing a receptive empty part of space (X), the atoms penetrate and move through X, without meeting any resistance whatsoever. Therefore, these passages are just as compatible with the receptive void concept (1,) as the surrounding one (2,).

Based on what has been said so far, there is no compelling evidence which might suggest that Epicurus' void was non-receptive. Now, I will mention some additional arguments, which attest the idea that his void was receptive, empty space. In this interpretation, the Epicurean void was quite similar to that of the early Atomists.[254] The evidence of Sextus Empiricus (*adv. math.*, x.2), and pseudo-Plutarch (*Doxographi Graeci*, pg 317) clearly supports the receptivity of void. It states that, in Epicurus, the same thing (or ἀναφής φύσις in Sextus Empiricus' version) is called "place" (τόπος), when occupied by a body, "space" (χώρα), when objects move through it, and "void" (κενὸν), if empty of bodies. In other words, κενὸν denotes the uninhabited part of the ἀναφής φύσις, which becomes τόπος, when filled by a body. This is equivalent to saying that void is empty space, which can be occupied (1,). Inwood rejects the above passages on the following grounds:[255]

A, The definition of τόπος as "something, in which objects are" is wrong, since the constant motion of atoms precludes the possibility of a place filled by stationary bodies. This objection is evidently wrong, since there are several other passages, which state that the ἀναφής φύσις is, "where" (ὅπου) bodies are (this is what τόπος refers to), and, "through which" (δι' οὗ) they move (χώρα).[256] Therefore, Sextus Empiricus' distinction between "space" and "place" seems justified. In addition, as Sedley points out, the passage could refer to perceptible compound bodies as well, which can remain stationary, although their constituent atoms keep oscillating within.[257]

B, Inwood denies the distinction between τόπος, χώρα, and κενὸν, and regards these terms as fully equivalent. However, the evidence which he adduces does not

[254] I have concluded that τὸ κενὸν of Democritus and Leucippus was probably receptive (see: III.1).
[255] Inwood, 1981, pg 281.
[256] Diogenes Laertius, x.40; Lucretius, *De Rerum Natura*, 1.503-5.
[257] Sedley, 1982, pg 184.

justify this claim. With respect to Diogenes Laertius (x.40), it is stated that there is "something, which we call void, space and intangible nature" (ἦν ὃ κενὸν καὶ χώραν καὶ ἀναφῆ φύσιν ὀνομάζομεν), which is not identical with saying that "void, space and place are fully equivalent". In addition, this statement is compatible with Sextus Empiricus (*adv. math.*, x.2), since there also the same thing (the ἀναφής φύσις) is called by different names.

However, it must be admitted that the passages in Diogenes Laertius do not clearly reflect the distinction between the three terms mentioned by Sextus Empiricus. Here, τόπος, χώρα, and κενὸν appear to be used interchangeably, with the preponderance of κενὸν, which is used in all the chief arguments, explicating the various characteristics of the concept.[258] In addition, κενὸν seems to play the role of both τόπος and χώρα in Diogenes Laertius. It is referred to as something "through which bodies move" (D. L., x.46, 61), a predicate, which properly belongs to χώρα (D. L., x.61). Elsewhere, κενὸν, and τόπος (both in the dative case) are used interchangeably as designations for the place "in which" a world system is generated (D. L., x.89). In this respect, the usage of τὸ κενὸν in Diogenes Laertius is analogous to its more general application (denoting both filled and empty space) in earlier Atomism (1,a), whereas, Sextus Empiricus' above distinction corresponds to the "narrower" meaning (1,b).[259] However, there is a difference. In early Atomism, there is no extant passage, which bears witness to the kind of distinction (between τόπος, χώρα, and κενὸν) present in the Epicurean corpus. This fact suggests that Epicurus, intending to make up for this omission of his predecessors, might have indeed clarified, and restricted the meaning of τὸ κενὸν. Nevertheless, Diogenes Laertius' evidence suggests that Epicurus also might have not observed the distinction consistently, and often used τὸ κενὸν in its wider, more general sense.

Does the above suggest that, for Epicurus, τόπος, χώρα, and κενὸν were fully equivalent? Are the passages in Diogenes Laertius irreconcilable with Sextus Empiricus' account? Strictly speaking, in Diogenes Laertius, Epicurus indeed

[258] Its infiniteness (D.L., x.42). The fact that "it offers no resistance" (D.L., x.46, 61). The fact that "it cannot be acted upon by bodies" (D.L., x.67).
[259] For (1,a) and (1,b), see: pg 76. For more on the usage of τὸ κενὸν in earlier Atomism and in Epicurus, see: Algra, 1995, pg 44-58.

disregards the distinction, and uses the word κενὸν even in those cases where other designations would be more appropriate. However, I believe that there is a reason why κενὸν is preferred over the other terms. Using frequently ἀναφής φύσις, which is a term not used in early Atomism, would have hampered the understanding of the arguments; whereas, using the more familiar word κενὸν facilitated understanding, and made it easier to relate the arguments to that of earlier Atomists. By contrast, τόπος, and χώρα are more general terms (employed even by those, like Aristotle, who deny the existence of empty space), and, unlike κενὸν, do not convey the essential characteristic of Epicurean space (that it has empty parts). That's why, in Diogenes Laertius, κενὸν acquires a wider meaning (and is used in a more general sense), and is said to be the place, where objects are, and, through which they move (properties properly belonging to τόπος, and χώρα respectively). In these instances, the restricted meaning of κενὸν, which refers only to the **empty** parts of space, would create a misunderstanding. After all, properly speaking, those parts of space where objects are and through which they move are no longer **empty**.

Accordingly, we can assign a dual meaning to κενὸν. In a narrower sense (corresponding to (1,b)), it only refers to the presently empty parts of space (this is the meaning defined by Sextus Empiricus). In a wider sense (1,a), κενὸν functions as the general name for the concept. In this latter sense, it features as subject in all the chief arguments (concerning Epicurean space), and possesses such predicates as "the place for bodies" or "through which bodies move", which could not be correctly predicated of it, if κενὸν was understood in its narrower sense. In addition, I doubt that Epicurus himself was especially intent on applying the distinction between the various terms for his ἀναφής φύσις consistently. He used them interchangeably, and, due to the above reasons, often chose κενὸν, even where τόπος, or χώρα would have been more appropriate. Nonetheless, even if, based on Diogenes Laertius, one entirely rejects the existence of a difference between τόπος, χώρα, and κενὸν, and states that these terms were fully equivalent for Epicurus (which entails that the evidence of Sextus Empiricus and pseudo-Plutarch must be disregarded), this statement neither refutes the receptivity of void, nor proves its non-receptive nature.[260]

A relevant passage of Stobaeus (*Doxographi Graeci*, pg 318) states that "τόπος, χώρα, and κενὸν differ in name". Inwood declares that this passage is incongruous with the ones in Sextus Empiricus, and pseudo-Plutarch. In his view, these three terms are proper synonyms (just like "taxi" and "cab"), and all of them denote the exact same thing. However, in Sextus Empiricus' interpretation, void, place and space are also names for the same thing (the ἀναφής φύσις), albeit in three different states ("being filled", "empty", or "traversed by a moving object"). Since the passage (*Doxographi Graeci*, pg 318) only calls for an identical underlying subject, and does not explicitly add that "the subject must be in the same state (for instance, in case of the 'surrounding' void, always empty of body) ", it is neither incongruous with the other passages nor incompatible with the receptive void. In fact, Sedley offers a possible interpretation of the passage, which conforms well to the receptivity of void: *"All three terms name the same thing, intangible extension. When bodies pass into and out of this, it remains unaffected in all but name."*[261]

Lastly, I will mention an additional argument, which proves the receptivity of void, and, at the same time, refutes the "non-receptive" interpretation. The Epicurean system postulates the existence of something, "where" (ὅπου) bodies can be, and, "through which" (δι' οὗ) they can move.[262] Looking at this statement in isolation, both the receptive (1,), and the surrounding (2,) void can fulfil this requirement. However, the inclusion of the restriction that void "can neither act nor suffer action" (οὔτε ποιῆσαι οὔτε παθεῖν δύναται),[263] entails the exclusion of (2,). After all, if void cannot suffer action, it cannot be displaced either, which makes it impossible for the surrounding void to act as something, "where" objects are and, "through which" they move. If we apply this restriction, Inwood's "fluid-like" void becomes unable to fulfil the above requirement. Therefore, we are left with the only available solution, which

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[260] Sedley also admits the lack of distinction between τόπος, χώρα, and κενὸν in Diogenes Laertius, while, at the same time, he maintains the receptivity of Epicurus' void (1982, pg 188-9).
[261] Sedley, 1982, pg 188.
[262] Diogenes Laertius, x.40; Lucretius, *De Rerum Natura*, 1.503-5.
[263]Diogenes Laertius, x.67.

is that void is empty space, which by dint of its receptivity, can provide place for the moving atoms (1,).

To conclude, there is no extant ancient source which could verify that the Epicurean void was some kind of surrounding, intangible fluid (2,); whereas, the receptive interpretation is clearly implied by Sextus Empiricus (*adv. math.*, x.2) and pseudo-Plutarch (*Doxographi Graeci*, pg 317). Even if we reject these sources, the restriction that "void cannot be acted upon", clearly precludes the non-receptive interpretation. Consequently, we can safely assume that Epicurus understood void as "empty space, capable of receiving bodies" (1,), and we can do so with more certainty than in the case of Democritus and Leucippus, where the evidence for the receptivity of void is less straightforward. Nevertheless, this means that, in my view, the void of the early Atomists and that of Epicurus and Lucretius was essentially the same. Therefore, in my analysis of the arguments for and against the existence of void, I will regard the void of both groups as receptive empty space, which, when occupied, becomes the place of the object. This will obviously impact the assessment of Aristotle's arguments, since Aristotle looked upon the Atomists' void in the same way. To mention an example, it entails that Aristotle is arguing against the "right thing", when refuting the existence of void in the *Physics*.

III.3 The arguments for the existence of empty space

After concluding what the Atomists understood under the concept of void,[264] let us consider the arguments, which attempt to either refute or corroborate its existence. Just as in the case of the size of the universe, with respect to the existence of empty space, Aristotle and the Atomists have opposing views. The latter assume it as one of the two basic features of our world alongside the atoms, whereas the former denies its existence. First, I will consider the arguments for void, and adduce Aristotle's reply

[264] By and large, in the following analysis, I will regard the Atomists' void as "empty space, capable of being occupied, in which case, it persists as the object's place", and evaluate the passages accordingly.

whenever it is relevant. Then, in (III.4), I will consider some additional Aristotelian passages, which attempt to refute the existence of empty space. As my analysis will reveal, neither side can provide an unshakeable proof for or against the existence of void, but the Atomists achieve more in this respect than Aristotle. I am referring to the Epicurean argument which at least manages to partly prove the existence of void (those parts of it which are presently occupied). In contrast, as I will demonstrate, neither of Aristotle's counter-arguments manages to refute the existence of empty space.

As we have seen (see: pages 80-1), Eleatic principles played an important role in the formulation of the early Atomists' void concept. In his "Way of Truth", Parmenides argued that only "what is" (ώς εστίν) exists, and "what is not" (ώς οὐκ εστίν) had no part in our universe. By virtue of the "what is" being a homogenous existence, which fills everything (πᾶν ἔμπλεόν ἐστιν), there can be nothing (not even emptiness) besides it.[265] Melissus equated the "what is not" (or "nothing" (μηδέν)) with the void, and denied the reality of locomotion on the grounds that it depends on void, which cannot exist.[266] Probably as a sign of their connexion to the Eleatics, the early Atomists retained Melissus' designation of the void as μηδέν (or μὴ ὄν), but argued that, in spite of being "nothing", empty space exists no less than plenum.[267] How did Leucippus and Democritus explain this apparent contradiction (the existence of something, called "nothing")? Since no extant passage contains the answer, we can only assume how they would have replied. Void is "nothing" in so far as it lacks all tangible qualities which bodies normally have. Nonetheless, this intangibility is not the same as "non-existence", and τὸ κενὸν indeed exists as empty parts of space separating the atoms.[268] Then, what are the reasons, which the Atomists adduce in order to prove its existence?

In the *Physics* (213b4-22), Aristotle provides a list of four arguments, which make people believe in the existence of empty space: 1, the argument for locomotion (b4-

[265] Parmenides, fr. 8.24; For more on the nature of Parmenides' "what is", see: Barnes, 1979, pg 176-180; Guthrie, 1965, pg 26-49.
[266] See: pg 80.
[267] Aristotle, *Metaphysics*, 985b7-9; Simplicius, *On Aristotle Physics*, 28, 11-2.
[268] More on this question, see: Bailey, 1928, pg 74-6; Barnes, 1982, pg 101-2; Furley, 1987, pg 119-120.

15); 2, compression (b15-8); 3, increase in size (b18-20); 4, an argument stating that the same vessel filled with ashes can contain as much water as in its empty state (b20-21). All involve empirical phenomena, which one way or another are dependent on void. Further on, Aristotle rejects these arguments by means of alternative explanations for these phenomena, which do not require void space.[269] Due to the nature of my subject matter, I am only interested in those arguments (for void), which can be related to Atomism. Can the above arguments ((1,)-(4,)) be attributed to the Atomists with certainty? What I mean is: did the Atomists reason in a similar manner as follows: P_1, if motion (or growth) exists, void exists; P_2, motion (or growth) indeed exists (as evidenced by the senses); C, void also exists?

Concerning (2,) and (4,), there is no extant evidence which could testify that either the early Atomists or the Epicureans argued from the reality of these phenomena to the existence of void.[270] Ross attributes (3,) to Leucippus, based on what Aristotle says about the reliance of "growth" on the void within the body (*De Generatione et Corruptione*, 325b3-4). However, Aristotle's statement that "growth is by means of the void" (διὰ τοῦ κενοῦ…τῆς αὐξήσεως),[271] does not entail that the early Atomists actually argued from growth to void. In order to entertain such an idea, the reality of growth needs to be presupposed (with certainty), based on empirical evidence. However, as I shall explain, unlike Epicurus, Democritus and Leucippus did not regard the evidence of the senses as entirely trustworthy. Therefore, it is not evident that the early Atomists produced something akin to (3,), and neither Aristotle nor the other sources mention it explicitly. With respect to Epicurus, although he indeed trusted in empirical evidence, which could have led him to argue from the observed phenomenon of growth to the existence of void (the latter being required for the process), no extant source preserved such an argument. In fact, the only detailed description about how growth (and decay) occurs comes not from Epicurus, but from Lucretius.[272]

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[269] I will return to these counter-arguments later on.
[270] See also: Ross, 1936, pg 582-3.
[271] Void intervals are necessary for the nourishment to "seep in" (ὑπεισδύεσθαι), and spread in the body (Aristotle, *De Generatione et Corruptione*, 325b4-5; *Physics*, 213b18-20).
[272] *De Rerum Natura*, 2.1105-1143; This passage only explains the process itself, and does not contain a "from growth to void" argument.

Concerning (1,), the fact that Epicurus argued from motion to void is reasonably well-attested by the evidence.[273] Whether the early Atomists reasoned in a similar manner is less straightforward. The only passage, which could serve as evidence for (1,), comes from Aristotle. This Furley regards as inconclusive, and states that, unlike Epicurus, the early Atomists did not even reason from motion to void in a strict sense.[274] The Epicurean passages recounting the argument indeed possess the required basic structure mentioned above $((P_1 \wedge P_2) \Rightarrow C)$. In contrast, Furley believes that the early Atomists did not reason directly from motion to void. Instead, they might have argued as follows: P'_1, Void is necessary for motion; P'_2, Void exists; C', Motion exists. This seems to be an argument "from void to motion", rather than the "from motion to void" version of Epicurus. However, I disagree with Furley, and consider it likely that even the early Atomists had something similar to (1,).

Furley bases his conclusion on the fact that the early Atomists did not regard empirical evidence as reliable in the way Epicurus did. The latter held that information gained from pure "sense-perception" (αἴσθησις), which does not contain additional discursive thought or "opinion" (δόξα), constitutes the only reliable source of knowledge.[275] In contrast, Democritus and Leucippus, were (probably) more sceptical towards the things we perceive through our senses. The relevant ancient sources seem to be contradictory: some present Democritus as believing in the senses, whereas others (especially the account of Sextus Empiricus) portray him as a sceptic, who rejects empirical evidence altogether.[276] Although, at first glance, it might seem impossible to resolve this contradiction between the sources, some modern scholars managed to reconcile these passages, and came up with a theory, which presents the early Atomists as more or less sceptical about the validity of sense-perception.[277] This is a lengthy and controversial topic, and I will only mention

[273] Diogenes Laertius, x.40; Sextus Empiricus, *adversus mathematicos*, viii, 314, 329 (Usener 272).
[274] The relevant passage: Aristotle, *De Generatione et Corruptione*, 325a23-7; Furley, 1987, pg 121.
[275] Diogenes Laertius, x.31-2 and 51; Bailey, 1928, pg 238-9 and 254.
[276] For the former, see: Aristotle, *De Generatione et Corruptione*, 315b9-10; *Metaphysics*, 1009b14-5. For the latter, see: Sextus Empiricus, *adversus mathematicos*, vii, 135-9. For an exhaustive list of relevant passages, see: Guthrie, 1965, pg 457-460.
[277] This is a controversial topic, but most scholars agree that the early Atomists were more sceptical about the information conveyed through the senses (sight, hearing …), and did not accept it at face value as Epicurus did. For the relevant discussions, see: Asmis, 1984, pg 338-50 (also includes a good

some general points, concerning how early Atomism regarded information from the senses. Then, I will show how, despite this "sceptical" view, Aristotle could still maintain that Leucippus accepted the reality of certain phenomena (motion, plurality of beings…) based on sense-perception,[278] a fact which, as I will demonstrate, enables the possibility of a "from motion to void" argument in early Atomism.

Our sources tell how Democritus observed that the same object can appear different to different individuals, which led him to question the validity of such perceptions.[279] In fact, as summed up by the following citation of Democritus, he probably went as far as to reject such sensation as colour, or taste, altogether and stated that, in reality only atoms and void exist.

"By convention sweet and by convention bitter, by convention hot, by convention cold, by convention colour; but by verity atoms and void"[280]

The "secondary" qualities, such as colour, taste or temperature, which belong to compound objects (not to the atoms), are contradictory and unreliable. It is only the atoms themselves, and their genuine attributes (shape, size, and motion), which constitute reality. However, due to the imperceptible nature of atoms, it is not possible to gain direct knowledge of these attributes either. Hence, in Democritus' theory, we are unable to perceive the true nature of the world, and *"either there is no truth, or it is hidden from us"*.[281] However, it is unlikely that Democritus was a complete sceptic, who rejected the possibility of attaining any kind of knowledge of the world. This is what the expression in Aristotle that, according to Democritus, the truth *"is hidden from us"* means.[282] It is "hidden" (ἄδηλον) in so far as we cannot perceive the qualities of atoms directly by our senses, but we still might attain knowledge of them through the "analysis" of our perceptions. In other words, sense-

literature on the subject (note 32 on page 346)); Bailey, 1928, pg 182-5; Guthrie, 1965, pg 454-465; Weiss, 1938.

[278] *De Generatione et Corruptione*, 325a23-5.

[279] Aristotle, *Metaphysics*, 1009b1-12.

[280] Sextus Empiricus, *adversus mathematicos*, vii, 135.

[281] Aristotle, *Metaphysics*, 1009b12-3.

[282] For the view that Democritus was not a complete sceptic, and knowledge (of atoms and void) can be attained from our perceptions, see: Guthrie, 1965, pg 461; Weiss, 1938, pg 49 (especially note 1).

perceptions are not discarded by the early Atomists, and they still represent the only media through which information about the atoms and void can be gained.

As Sextus' account relates, Democritus distinguished two kinds of knowledge. On the one hand, there is "dark knowledge" (γνώμη σκοτίη), which originates from our senses (sight, hearing…), and concerns perceptible objects (this is considered invalid). On the other hand, there is the "legitimate knowledge" (γνώμη γνησίη), which is attained by "rational thinking" (λόγος), and has the atoms and void as its objects.[283] Bailey and Guthrie seem to suggest that those qualities, which are common to both atoms and perceptibles (shape and size), provide us with reliable knowledge even as attributes of compound bodies.[284] However, I think their conclusion is not confirmed by evidence, and other authors (like Asmis, Furley and Weiss) do not draw such a conclusion. In addition, the idea that the shape of a perceptible object constitutes "true" or "legitimate" knowledge seems to contradict those passages, which state that, according to Democritus, "truth is hidden" or "truth is in the depths".[285] After all, if the shapes of all macroscopic bodies around us were considered true knowledge, these passages would not assert that the truth is hidden from us. A citation preserved by Sextus (*adv. math.*, vii.139), also says that *"to the 'dark' (knowledge) belong all these: sight, hearing, smell, taste, touch."* In other words, all sense-perceptions, even the shape of my laptop in front of me, are γνώμη σκοτίη.

Therefore, the only attributes, which constitute reality, are the shape (or size) of the atoms themselves, and the shape of perceptible bodies does not belong to this category. It must be repeated that I do not think that the perception of shape (or size) of macroscopic bodies constitutes γνώμη γνησίη. It is only the atoms and their genuine attributes which belong to this category. Nonetheless, even "legitimate knowledge" can be attained from perceptions by "going below our perceptual level", and, through the exercise of "rational faculty" (λόγος), inferring knowledge about the imperceptible world (the atoms and void).[286] Hence, this way it is possible to

[283] Sextus Empiricus, *adversus mathematicos*, vii, 138-9; Although the passage does not state explicitly that the objects of γνώμη γνησίη are the atoms and void, it is concluded by Weiss (1938, pg 48), and supported by the fact that it is only the atoms and void which are real.
[284] Bailey, 1928, pg 184-5; Guthrie, 1965, pg 463.
[285] For instance: Aristotle, *Metaphysics*, 1009b12; Diogenes Laertius, ix.72.
[286] Guthrie, 1965, pg 462-3; Weiss, 1938, pg 49-50.

produce theories concerning atoms and void, which originate in and are in accordance with sense-perception. This is exactly the position, which Aristotle attributes to Leucippus, when saying that *"he had a theory which harmonized with sense-perception and would not abolish either coming-to-be and passing-away or motion and the multiplicity of things."*[287]

However, I believe the subsequent line (325a26) goes a bit further, and indicates that Leucippus, based on the evidence of the senses, accepted motion (and the other above mentioned phenomena) as real and existing.[288] What I intend to prove is that, according to this passage, Leucippus, based on the rather straightforward experience that objects move, acceded to the simple fact that motion exists. As I see it, the phrasing of a26 that Leucippus "conceded (the reality of) these things (movement …) to the appearances (empirical data)" (ὁμολογήσας ταῦτα μὲν τοῖς φαινομένοις) suggest that, according to Aristotle, Leucippus indeed accepted the existence of motion on empirical grounds (let us denote this proposition with (a,)). Besides its function in (a,), ὁμολογέω (with the dative case) is also used to express that the early Atomists adopted the Eleatic principle (the argument of Melissus) that "there can be no motion without void" (b,).[289] The using of the same word for both (a,) and (b,) implies a strong connexion between the two statements. Although implicit, such relation between (a,) and (b,) entails that Aristotle could have had an argument in mind, which combines "the reality of motion" (a,) with Melissus' reasoning (b,) to produce some form of "from motion to void" argument. In other words, according to this rendering of the passage, the early Atomists adopted Melissus' argument, but, unlike Melisuss, they conceded the reality of motion, and, therefore, they were able to use it as a premise when arguing for void.

[287] *De Generatione et Corruptione*, 325a23-5.
[288] In this respect, my interpretation agrees with that of Joachim (1922, pg 162).
[289] *De Generatione et Corruptione*, 325a26-7; The phrase ὁμολογέω (with the dative case) means to "concede to something". In the text, both τοῖς φαινομένοις and τοῖς τὸ ἓν κατασκευάζουσιν are in the dative case (and governed by ὁμολογέω), which means that Leucippus both conceded to the reality of sense perception (in respect of motion, generation …), and to the Monists (τοῖς τὸ ἓν κατασκευάζουσιν) (to Parmenides and Melissus), who held that "if there were such a thing as motion, it would require the existence of empty space".

Is the above mentioned incongruous with the fact that the early Atomists regarded sense-perceptions as invalid? I do not think so. As we have seen, Aristotle's passage (*De Generatione et Corruptione*, 325a23-8) clearly implies that Leucippus did not question the reality of motion. In fact, motion is never listed among the qualities whose validity the early Atomists questioned. These latter were such qualities as colour, temperature, or taste, which did not belong to the atoms directly. In contrast, motion, besides shape and size, does indeed belong genuinely to the atoms, which were considered the only real material existents (this entails that the qualities belonging to them (shape, size and motion) are more real than the qualities exclusive to perceptible bodies (colour, temperature …)).[290] Therefore, unlike in the case of colour or taste, I do not think that Democritus or Leucippus questioned the reality of motion.

Consequently, based on Aristotle's passage, which is the only available, pertaining evidence, we can safely assume that Democritus and Leucippus accepted the existence of motion on empirical grounds, and the above mentioned connexion (between (a,) and (b,)) implies that, they (probably) used the fact that "motion is real" when arguing for void. In other words, the early Atomists (probably) had some form of "from motion to void" argument as well. After all, through Melissus, they were no doubt familiar with (1,),[291] and it seems reasonable to assume that they used it for their own purposes. In addition, it would appear strange that Epicurus, as part of his own argument for void, relied on Melissus, whereas his predecessors, despite being much closer both in time and thought to the Eleatics, did not. Rather, it seems more reasonable to suppose that some kind of "from motion to void argument" had already been present in Atomism, and Epicurus simply rephrased it in his own terms.[292]

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[290] Although, it must be mentioned, that, being imperceptible, we cannot have direct knowledge about the motion of atoms. In addition, it does not mean that the shape (or motion) of a perceptible object is as real as that of an atom (see: pg 100-1). It only means that, the fact that shape (or motion) as a quality exists is rendered valid by the following: 1, it is never grouped together with "illusionary" attributes, like colour or taste. 2, Atoms, which are the only real existents, also possess them (but not the others).

[291] For the numbering of the various types of arguments for void, see: pg 96-7.

[292] Ross, in his commentary, also states that Aristotle attributes (1,) to the early Atomists, and does not raise any doubts concerning the possibility of such an argument (1936, pg 582).

Then, let us see in what manner the Atomists argued from the phenomenon of motion to the existence of empty space. Epicurus' argument was preserved by Diogenes Laertius (x.39-40), and we also have Lucretius' version (*De Rerum Natura*, 1.420-9). With respect to the early Atomists, the one recounted by Aristotle (*Physics*, 213b4-14) is not attributed explicitly to the Atomists. However, since we have no other pertaining evidence, and, since I have demonstrated the possibility of a "from motion to void" argument in early Atomism, I will include it into my analysis. The argument applies *reductio ad absurdum* to demonstrate the impossibility of motion without empty space. It presupposes: a, the "full" (πλῆρες) cannot receive another object into itself (213b6-7); b, there is no void. Then, from (a,) and (b,) follows the impossibility of movement, which is absurd, since our senses attest the reality of motion.[293] Assuming (b,), what is full must "receive" (δέχεται) other bodies into itself, in order for motion to occur (a,). This in turn leads to the absurd consequence of two bodies coinciding (b7). From which it follows that any number of bodies can occupy the same place (b8), and even the smallest object can receive the largest (b9-11). For if a space can accommodate two objects, it can do so with an indefinite number of them. Also, since every object is divisible into arbitrarily small parts, even the smallest can accommodate the largest in sufficiently small increments. Since these absurdities result from (a,), (a,) cannot be true. Therefore, either there is no motion, or if there is, (b,) ought to be false. Consequently, there must be empty space to admit of movement.

Aristotle's reply to the argument is at 214a28-32. He argues that change of place does not entail (a,) (and its impossible consequences) even if we uphold (b,). In other words, void is not necessary for locomotion, since objects are able "to give way to each other" (ὑπεξιέναι ἀλλήλοις).[294] Aristotle's reply is probably connected to Melissus, whose name is mentioned both in the description (213b12-4) and in the refutation (214a27-8) of the argument. For Melisuss argued that, if "emptiness" (τὸ

[293] This additional premise that "(based on empirical evidence) motion exists" is not present in the argument, and needs to be supplemented. In the previous pages, I have already demonstrated that, despite their overall sceptical attitude to empirical evidence, the early Atomists (most probably) accepted this premise.

[294] The process where bodies "make way for" (or replace) each other is referred to as "replacement" (ἀντιμετάστασις) by Aristotle (See: *Physics*, 208b1-7, 211b14-29, 215a15).

κενὸν) existed, body (or "being") "could give way into the emptiness" (ὑπεχώρει ἂν εἰς τὸ κενόν).[295] However, Aristotle replies that the ability to yield is not exclusive to the void, but bodies can "give way" to each other as well. He gives the "rotation of continuous (solids) and liquids" as examples to illustrate this mutual replacement (a31-2), where the parts replace each other during the rotation. However, in these cases, the position of the object as a whole does not shift. Since it is not change of place in the strict sense, revolution around a fixed axis is not the kind of motion from which the Atomists would have concluded the existence of empty space (revolution can be explained without void). Therefore, it might be easier to understand this "yielding" ability of matter, if we regard how surrounding fluids retreat from the moving object, then, fill the space behind it. Interestingly, Lucretius uses this same example to prove the existence of void (*De Rerum Natura*, 1.370-84). When an object moves in water, the latter is able to yield, by virtue of the fact that moving body leaves behind empty space into which the water can flow. Lucretius' conclusion is rather unique, since "motion in a surrounding medium" is usually not associated with void.[296] In fact, both when the object is stationary and the surrounding fluid moves (for instance, in case of a protruding rock in a stream), and when the body moves in the medium (like fish in a lake), it is possible to imagine the phenomena without empty space.

All in all, if it is supplemented by the above "motion in fluids" example, Aristotle's alternative account (214a28-32) seems to adequately explain how movement is possible without empty space. Consequently, it appears that he successfully demonstrates that the empirical truth that "motion is real" does not necessarily entail the existence of void. However, there is a problem: the process of "yielding" is only possible without the generation of void intervals between the objects, if matter is continuous and divisible ad infinitum. For instance, when water gives way to the sinking stone, its shape must constantly adapt to that of the stone (must surround it tightly), otherwise void intervals will be left in-between. In order to do this, its matter must consist of infinitely small particles, which can continuously surround the moving

[295] Melissus 30 B 7 in Diels-Kranz.
[296] Hussey, in his commentary, also gives a similar example to illustrate how movement is possible without void (1983, pg 127).

object without leaving gaps. In other words, it must be infinitely divisible, an attribute which Aristotle indeed attributes to all material substances.[297] From this, it follows that a body can be divided at any point (there is no smallest particle, which might resist the attempt), and can assume any conceivable shape, a fact which enables water to surround the object without gaps. However, the Atomists reject infinite divisibility, since their atoms can no longer be divided further. Hence, in their theory, the water atoms are unable to "follow" the sinking object's shape perfectly, and leave empty gaps. Since Aristotle`s alternative explanation (214a28-32) relies on infinite divisibility, it does not work against the Atomists. Consequently, as long as matter is regarded as finitely divisible, the Atomists` argument (213b4-15) holds, and empty space seems to be necessary for locomotion.

As a matter of fact, Epicurus, who was probably familiar with Aristotle's above refutation, indeed retained the "from motion to void" argument (Diogenes Laertius, x.39-40). Both he and Lucretius utilise it as their chief argument for the existence of empty space. Lucretius' version (*De Rerum Natura*, 1.426-7) is just a repetition of what Epicurus previously said (Lucretius even kept the same predicates for void), so I will focus on Epicurus' passage. At first, Epicurus states his fundamental doctrine that there are two basic constituents of the universe: bodies and void (σώματα καὶ κενόν). The existence of the former is not in question, since everyone can perceive bodies.[298] However, empty space cannot be perceived directly. Therefore, an argument is required to prove its existence. The following is presupposed: 1, bodies exist; 2, bodies move (both (1,) and (2,) are based on ἄισθησις). However, if there were no void (κενόν, "space" (χώρα), or "intangible nature" (ἀναφής φύσις)), there

[297] Unlike the Atomists, Aristotle held matter to be (potentially) infinitely divisible (*Physics*, 206a16-7, 207b4, 239b9). I will talk more about the arguments concerning divisibility in chapter IV.

[298] Bodies exist, because "perception from everyone bears witness to it" (ἄισθησις ἐπὶ πάντων μαρτυρεῖ). In Epicureanism, "information coming from the senses" (ἄισθησις) is reliable, and used to confirm the validity of concepts and theories. What is more, a concept is valid in so far as there is either "witnessing" (ἐπιμαρτύρησις) by the senses (this is what μαρτυρεῖ refers to), or, in cases where direct perception is unavailable, "no counter-witnessing" (οὐκ ἀντιμαρτύρησις). For a detailed discussion on the validity of sense perceptions, see: Asmis, 1984, pg 83-166 (on "witnessing", see: pg 143-5).

would be nothing where objects could exist,[299] and "through which they could move" (δι᾽ οὗ ἐκινεῖτο). In other words, (1,) and (2,) could not hold, if there were no void.

Is this correct? Is the assumption of the Atomists' receptive empty space, which can accommodate bodies, the only way to make both (1,) and (2,) true? Taking (2,) separately, as we have seen, the only alternative explanation (*Physics*, 214a28-32), which does not require void, depends on infinite divisibility. Therefore, it cannot be used to refute Epicurus` reasoning. Turning to (1,), is it possible to explain "being in a place" differently from Epicurus without assuming a kind of three-dimensional spatial entity (like the Atomists' void)? Aristotle's notion of place (at least, as it is present in his *Physics*) indeed constitutes a different solution.[300] In the *Physics*, Aristotle formulates the definition of an object's "place" (τόπος), according to which, it is the "limit of the surrounding object" (τὸ πέρας τοῦ περιέχοντος σώματος). As a "limit" (πέρας) of a three-dimensional body, place becomes a two-dimensional surface, quite different from the three-dimensional receptive void of the Atomists. However, this notion of place as "inner bound of the container" also raises some difficulties, including the problem about the place of a body, during its locomotion.[301]

Basically, certain of Aristotle's requirements for "place" are incongruous with each other, if either the object or its surroundings (for instance, water) are in motion. The relevant requirements are: a, place should be the first (or closest) limit surrounding the body (*Physics*, 210b34), it should be similar in size (211a2), and "contiguous"

[299] The fact that there must be something "**where** bodies can be" (τὰ σώματα **ὅπου** ἦν) follows from (1,). Since we perceive bodies around us (and our perceptions are true), objects must exist in a material sense, and they must have a spatial location.

[300] Most scholars argue that, in some passages outside of the *Physics* (especially, in chapter 6 of the *Categories*), which probably predates the *Physics*), Aristotle seems to regard "place" as a three-dimensional extension, which exists independently (not as part of) the object, which occupies it. However, this "three-dimensional extension" as place, is clearly rejected by the *Physics* (211b14-29). In other words, Aristotle's earlier notion place seems to have been different than the one argued for in the *Physics*. For an extensive general discussion on the matter, including list of sources, see: Algra, 1995, pg 123-36 and 182-90.

[301] Another difficulty, for instance, is whether the outer sphere of the Aristotelian heaven is "in a place" or not, and, if not (after all, there is no body to surround it), how can it rotate (Algra, 1995, pg 185, pg 235-6; Hussey, 1983, pg 119-20; Sorabji, 1988, pg 194-6)? For a general discussion concerning problems raised by the *Physics'* definition of place, see: Algra, 1995, pg 234-7; Sorabji, 1988, 186-215. For an attempt to rescue Aristotle's definition from these problems, see: Morison, 2002, pg 133-173.

(ἅπτεσθαι) with its object (212b19-20);[302] b, place should remain "immobile" (ἀκίνητος), even when the object moves (212a14-21).

Let us suppose a situation, where either the body or the medium or both move (as in case of a boat in a river). In such case, (b,) entails that the water, which immediately surrounds the boat, cannot be its place (since it is in motion in relation to the boat). From this, Aristotle concludes that it is not this layer of water, which is the place of the object, but the whole river (212a19). So, under this interpretation, place becomes the "first unmoved limit" (πέρας ἀκίνητον πρῶτον), surrounding the object. In case of the above example, the place of the boat would be the riverbed, which is the "nearest immobile limit". Before proceeding further, it is necessary to ascertain the proper sense in which Aristotle regards place as "immobile" (ἀκίνητος). The requirement of (b,) is that τόπος which is the περιέχοντος πέρας should be ἀκίνητος. From this, it seems reasonable to suppose that the immobility requirement refers directly to the surface surrounding the object. Under this interpretation, only those surfaces can be admitted which undergo no movement whatsoever. For instance, the constantly flowing water of the river cannot fulfil the requisite. This is why, when providing the "first unmoved limit" for the boat, I refer to it as the "riverbed" (the unmoved surface of the ground adjoining the river).[303]

However, the riverbed as place cannot meet the requirements of (a,), since it is neither contiguous with, nor the same size as the boat. Consequently, these attributes must be abandoned, if we take place to be the "first immobile limit" as defined by Aristotle at 212a20. However, this understanding of place entails certain absurdities: for instance, a ferry crossing the river (and moving at right angles to the flow of water), despite its movement, would always have the same place (the corresponding section of the riverbed). In addition, boats aligned next to each other

[302] Based on the definition in the *Physics* (226b23), two bodies are said to be "contiguous" (ἅπτεσθαι), when their "extremities (surfaces) are together" (ὧν τὰ ἄκρα ἅμα), where "together" (ἅμα) means to "occupy the same place" (b21-2). In respect of place, this means that the surface of the object, and the inner surface of its container are "together" (they are in the same place).

[303] Strictly speaking, the passage (212a14-21) uses the expression "the whole river" (ὁ πᾶς ποταμός), and not "riverbed". However, if we want place to be a surface (this is clearly required by Aristotle), we should understand Aristotle as looking for the first immobile limit (and not for a three-dimensional entity), which is the place of the whole river, the riverbed. Both Hussey (1983, pg 117) and Sorabji (1988, pg 188) interpret the passage in this manner.

(and at right angles to the flow of water) would have the same section of the riverbed as their places (although, in reality, they occupy different locations).

However, if we disregard the "immobility" requisite (b,), and keep the original definition of 212a5-6,[304] certain absurdities still remain. For instance, in case of a moving jar filled with wine, the wine would not change its own place (the inner surface of the jar stays to be its place), despite being carried around in the jar. In light of these difficulties, we can say that, although Aristotle explains how motion is possible without void, with respect to the explanation of movement (the requirement of (2,)), his own definition of place does not fare well.

Morison, in his attempt to rehabilitate the *Physics'* definition of τόπος, contrives a possible solution to the above difficulties: it would be to abandon the requirement that the surrounding surface itself needs to be immobile. Rather, we should regard its motion or rest as deriving from its host. In this sense, the riverbed is at rest by virtue of the body (the whole earth) to which it belongs being immobile.[305] Based on this, the same surface can be regarded as moving and motionless at the same time. As Morison explains, the status of the "limit" (πέρας) around the object depends on how we identify its host body. In the river example, in so far as it belongs to the flowing body of water, the surface surrounding the boat moves. In contrast, taken as the limit of the river itself, it is motionless, since the river as a whole does not change its place.[306] Therefore, when ascertaining the place of the object, one should not look for the first stationary surface (this is what we did when identifying the first unmoved limit with the bank of the river) which might yield places not in immediate contact with the object (hence, failing to fulfil the requirement of (a,)). Instead, since the surface derives its status from its host, we should look for a stationary body to which

[304] Evidence suggests that, in the *Physics*, Aristotle indeed kept (or reverted to) the definition mentioned at 212a5-6 even after revising it at 212a20 (Sorabji, 1988, pg 188). In other words, he continues to regard place as "the immediate surrounding limit", which is contiguous with its object (212a29-30, 212b19). In fact, Aristotle appears to be oblivious to the contradictions (between the two forms of definition), and makes no mention of them.

[305] Although in reality, the earth undergoes complex motions, in Aristotle's system, it is at rest in the centre, and does not revolve. Therefore, a part of its surface (the riverbed) can also be regarded as motionless.

[306] Morison, 2002, pg 150-2; For the idea that the surface derives its immobility from the host body, see: Burnyeat, 1984, note 15 on page 232.

the surface also belongs (in the above case, the whole river).[307] Therefore, the inner limit of the river surrounding the boat becomes its proper immobile place. Although it is constituted by moving and changing water surfaces, in so far as it is the limit of the river, it remains motionless.

This way, the above difficulties seem to be resolved, since we defined a place which is both stationary and adjoining to its object. In fact, Morison goes even further when saying that the "surrounding body" in the definition of τόπος should be understood as the whole universe.[308] Since the universe as a whole neither moves nor alters its shape, regarding the containing limit as that of the universe, it is possible to assign an immovable place to any of the objects within it. However, there are certain problems with this interpretation. For instance, the underlying idea that the surface's immobility is derivative creates some difficulties. As long as we consider relatively "static" bodies such as the earth, the immobility of their surfaces seems straightforward. However, as Sorabji points out, in the case of fluids, whose internal organization is in constant change, it is difficult to regard their inner surface as having the same status (either motion or rest) as the whole body.[309]

Due to the fact that, in most cases, objects are surrounded by such changeable mediums, the derivativeness of surfaces cannot be applied to Aristotle's place theory without reservations. One possible way to solve the problem is to regard place as a relation. Under this interpretation, although being constituted of ever-changing water surfaces, the πέρας surrounding the moored boat, which is its proper Aristotelian place, would indeed remain stationary by virtue of its fixed relation to an immobile body (be it the whole river or the universe). By "fixed relation" I mean that the distance and direction between the points of the limit and the centre of the universe (or the banks of the river) remain constant over time. If the boat moves from point A to point B ($A \neq B$), it will be encircled by πέρατα, each with a different relation to the whole river (the boat will occupy different places during the motion).

[307] Although its constituent water is in constant motion, considering a sufficiently short time-span, the river as a whole does not change its course. Consequently, in so far as it has a reasonably fixed geographical location, the whole river can be regarded as stationary.
[308] *ibid*., pg 138, 146-7.
[309] For a more detailed explanation, see: Sorabji, 1988, pg 190-191.

Consequently, under this "relational" interpretation, Aristotle' theory seems to adequately explain both motion and rest. However, the problem is that there is no evidence that Aristotle regarded place in this manner. For instance, no text supports the idea that, for Aristotle, a limit is ἀκίνητος by virtue of having a fixed relation to the whole universe (or to its centre). Although Aristotle might have regarded the motion or rest of surfaces as deriving from their host body (as we have seen, this idea is also problematic), he nowhere implies that either movement or rest are ascertained by relations between fixed spatial points.[310] Consequently, due to the lack of evidence, the idea that Aristotle's place theory is "relational" should be dismissed. Therefore, if we do not want to venture too far from Aristotle's own ideas, references to relations between fixed points cannot be applied to address the problems which beset the *Physics'* place theory.

As I see it, this fact excludes Morison's attempt to rehabilitate Aristotle as well, since even his interpretation of Aristotle's place theory (see: above) is dependent upon the above dismissed relational approach to successfully explain motion and rest. Morison seems to deny this, and argues that movement and rest can be distinguished by the fact that only the former state causes the universe to "rearrange" its parts around the moving object.[311] However, I believe this to be an inadequate way to distinguish the two states. After all, the universe can rearrange its parts even around a stationary object (in reality, most of the parts of the universe are in constant movement),[312] and I see no trustworthy method to safely distinguish this latter form of rearrangement from the one triggered by the moving body. In fact, when explaining the position or movement of an object Morison also writes things like "we can say where the boat is by locating it relative to the river" or "things have place relative to the immobile universe", which shows that he is also forced to rely on the relational approach to define position or discern movement from rest.[313]

[310] See also: Hussey, 1983, pg 117; Sorabji, 1988, pg 190.
[311] Morison, 2002, pg 147, 149.
[312] Even if we regard the Aristotelian Cosmos, where a person standing on the earth's surface can be considered stationary (since the earth itself is motionless), the air around him (the parts of the universe surrounding that person) is in constant motion.
[313] *ibid*., pg 149, 151.

All in all, in deference to the difficulties it entails, Aristotle's theory of place did not have many adherents in antiquity,[314] and neither we nor Epicurus are compelled to accept such a theory. In fact, due to the problems it entails, Aristotle's interpretation of place as surrounding surface can be dismissed. Consequently, the assumption of a "separate" spatial entity (not a surface, like in Aristotle, but three-dimensional) seems to be the only solution for (1,).[315] After all, the requirement of (1,) is that there must be something, where objects can exist in a material sense (see: note 299). If we add the additional requirement that this thing which enables objects to exist somewhere does not belong to the objects as an attribute (for instance, it is not their "form" in the Aristotelian sense of the term), but is independent of them,[316] the supposition of a three-dimensional spatial entity, which can provide location, appears to be the only solution. However, since the existence of bodies only substantiates occupied space, this does not prove that there are void (currently empty) parts of this "space" as well. For this latter proof, we need to suppose that these objects are in motion. In this latter case, unless their respective "places" move alongside the bodies,[317] they are left behind, and previously void intervals are required into which the objects can move. In other words, (2,) appears to hold, and the existence of motion indeed entails that of void.

[314] Most thinkers following Aristotle, rejected his concept of "place" as the surface of the surrounding body (Sorabji, 1988, pg 199). Aristotle`s pupil and successor at the academy Theophrastus and Strato after him also abandoned the concept of place as a two-dimensional surface (Simplicius, *On Aristotle Physics*, 601, 24, 604, 5-11, 618, 24). Due to the *aporiai* it entails, Aristotle`s definition of place received extensive criticism in ancient times (see: Simplicius, *On Aristotle Physics*, 601, 25-611, 10 (includes Theophrastus` list of the aforementioned *aporiai* at 604, 5-11); Philoponus, *On Aristotle Physics*, 563, 26-567, 29). In fact, the view of space as a three-dimensional extension was much more prevalent. Under my interpretation, the Atomists shared this latter view (see: first half of this chapter). In addition, most Platonists and Strato (Simplicius, *On Aristotle Physics*, 601,24, 618,24; Philoponus, *On Aristotle Physics*, 567,29-569,17), and the Stoics (Sextus Empiricus, *adv. math.*, 10.3; Simplicius, *On Aristotle Physics*, 571,22-6) also entertained the three-dimensional interpretation.

[315] For the description of (1,) and (2,) in Epicurus' argument, see: pg 105-6.

[316] Both Aristotle, and Epicurus held place to be "separable" from the occupying body. In other words, place must be left behind by the moving object (and not accompany it). This kind of independence from the object is one of the basic requirements for τόπος in the *Physics* (208b1-8, 209b23-28). Otherwise, certain absurdities would follow, during locomotion. For instance, during replacement, two objects replace each other in the same place (for instance, in a vessel). We observe that where body "X" was formerly, body "Y" comes to be. However, if place was inseparable, both X and Y would carry around their respective place, and not just bodies, but places also would replace each other in the vessel. An absurdity, which contradicts our observations. Therefore, Aristotle concludes that an object's place is "separable" (χωριστός) from it.

[317] Neither the Atomists nor Aristotle regarded place as mobile, and moving with the object.

Ultimately, the answer to the question whether "it is possible to argue from motion to empty space, or not", depends on the divisibility of matter. If it is infinitely divisible, Aristotle's alternative explanation to motion which does not involve void is acceptable, which renders the "from motion to void" argument invalid. In the opposite case, Aristotle's refutation does not work, since **empty** gaps must remain between the object and the surrounding medium, during movement. However, considering the other premise of Epicurus' argument (1,), after we excluded Aristotle's two-dimensional concept of place, the only remaining solution is that there must be an independent, three-dimensional spatial entity where objects can exist in a material sense. This entity equates with the occupied parts of Epicurus' void.

All in all, these arguments for void (*Physics*, 213b4-15; *De Gen. et C.*, 325a23-7; Diog. L., x.39-40) manage to substantiate the existence of filled space, but the proofs for its empty parts are not without qualification. So, let us look for another argument for void. In order to do this, we must return to Aristotle's passage (*De Generatione et Corruptione*, 325a25-6), where, alongside movement, the observed "multiplicity of existent things" (τὸ πλῆθος τῶν ὄντων) is also said to be a phenomenon which was considered real by Leucippus based on empirical evidence.[318] The fact that the "plurality of things" is mentioned alongside motion in the same context, leaves open the possibility of an argument which has its premise the observed fact that many separate (or individual) things exist. Is there such an argument (following the list of arguments ((1,)-(4,)) on pages 96-7, let us refer to it as (5,)) which exploits this premise to prove the existence of empty space? There is a brief reference to such a reasoning in *De Generatione et Corruptione* (325a4-6). However, here Aristotle probably relates a Pythagorean argument, and not something belonging to Atomism.[319] This argument states that neither motion, nor "to be many" (πολλὰ ἒιναι) is possible without void, and the "plurality of things" depends on void in so far as the latter is required to "separate" (διείργω) the individual things.

[318] For the reasons why motion and "the plurality of things" were (probably) considered real by the early Atomists, see: pg 101-2.
[319] For references to this Pythagorean notion that void is needed to separate individual things, see: Aristotle, *Physics*, 213b22-7, *Metaphysics*, 990a22-7. See also: Joachim, 1922, pg 159-60.

Although the early Atomists or the Epicureans might well have used the observed phenomenon, the "plurality of existents, which appear to be separated from one another", to argue for empty space,[320] we have no ancient evidence which could testify to this fact. In fact, whenever mentioning it, Aristotle consistently connects (5,) to the Pythagoreans (and not to the Atomists), which seems to imply that the Atomists did not argue (or at least not explicitly) in this manner. Therefore, I will also not attribute such reasoning to the Atomists. In addition, unlike in the case of "from motion (or increase) to void", Aristotle nowhere provides a direct refutation of (5,).[321] Consequently, this will not feature in my subsequent analysis, in which I will consider some additional Aristotelian arguments against void.

As we have seen, the only substantial arguments for void, which are, or might have been used by the Atomists are: the ones recounted by Aristotle, which reason from movement (*Physics*, 213b4-15; *De Gen. et C.*, 325a23-7); the Epicurean version of the argument (Diog. L., x.39-40; *De Rerum Natura*, 1.426-7) which includes an additional premise (see: (1,) on page 105). By virtue of this latter premise, the existence of occupied void is proven. In contrast, the proofs for the empty parts of space are not conclusive (see: Aristotle's counter-example, and the problem of infinite divisibility).

III.4 Further arguments against the existence of empty space

In this part, I will consider some of the refutations, contained within Aristotle's most extensive discussion on void (*Physics*, book IV.6-9). I will also include relevant arguments directed against "place" as a three-dimensional extension (209a2-7, 211b14-29). Besides these passages, there is another brief argument against the possibility of extra-cosmic void found in *De Caelo* (279a11-8) which I have already

[320] After all, void accounts for the separation of individual objects.

[321] The passage in *De Generatione et Corruptione* (325a1-16), which includes the Pythagorean argument, does not contain Aristotle's own refutation of (5,). Rather, it is a brief summary of the Eleatic view, which rejected (5,), and argued: since void is "not-being", it cannot exist. Hence, without void, there is nothing to separate the individual objects. Therefore, the universe consists of a continuous (un-divided) whole.

refuted in the previous chapter.[322] I will conclude that both the arguments against three-dimensionally extended place and the ones aimed directly at void fail to fulfil their purpose. In each case, I will highlight the problems inherent in Aristotle's reasoning, and the reason(s) why neither of his arguments succeeds in refuting the existence of empty space.

The refutations of the *Physics* are structured in the following manner (I am singling out those parts, which are relevant to my discussion):

I, At first, Aristotle defines the sense of void which he intends to refute. He concludes that void is defined as "place" (τόπος), which can accommodate bodies, but currently it is unoccupied.[323] As I have said (see: III.1-2), by and large, this kind of interpretation of the concept is identical to the one which can be attributed with reasonable plausibility to the Atomists.

II, Aristotle lays down the most common arguments (of others) against (213a22-b2), and in favour of the void (213b2-29). The former consist of a single line of reasoning which Aristotle dismisses right away. The latter is a set of arguments from certain apparent phenomena to the existence of void (see: (1,-4,) on pages 96-7). Aristotle rejects them by means of alternative explanations which do not include empty space (214a22-b11). In the last part of the chapter, Aristotle includes an additional theory concerning "condensation" and "rarefaction" (216b22-217b20), which is related to the argument from "compression" ((2,) mentioned at 213b15-8). At first, the positive argument for void is stated (216b22-30), and reiterated (217a10-20). Then, Aristotle refutes it by showing that empty space cannot account for these phenomena (216b30-217a10), and adduces his own alternative explanation (217a20-b10).

III, Arguments aimed at substantiating the impossibility of void: a, some general problems about motion in empty space (214b12-215a24); b, arguments, where Aristotle presupposes certain kinetic laws, and demonstrates their incompatibility

322 For the problems relating to this argument, see: chapter II, pg 24-6.

323 *Physics*, 213a15-8, 214a11-2, 214a 16-7;

with void (215a24-216a23); c, problems which arise, when the void is occupied by objects (216a23-b21).

The principal focus of my subsequent analysis will be on the arguments of (III,), because these are the ones which are designed to refute the existence of empty space directly. In contrast, the ones at (II,) are mainly concerned with refuting the arguments for void mentioned at 213b2-29 by giving alternative explanations to the phenomena which do not depend on void.[324] At first, I will consider two passages directed against "place" as a three-dimensional extension (209a2-7, 211b14-29). It is advantageous to start with these, since, in the subsequent discussion on void (book IV.6-9), Aristotle refers back to the conclusion of these arguments more than once. In particular, since the notion of place as a separate, three-dimensional extension has already been refuted, Aristotle states that void, which is place deprived of body, also cannot exist in this sense.[325] This originates from the following: 1, place cannot be a three-dimensional extension (the conclusion of 209a2-7 and 211b14-29); 2, void is a kind of place. As we shall see, (1,) excludes the possibility of empty place, since it cannot extend in three directions to create empty "volumes". Since (2,) states that void is place as well, due to (1,), its existence is an impossibility. Besides the rejection of a "three-dimensional" place (1,), the *Physics'* definition of it as the "limit of the surrounding body" also does not admit of void space, since this definition renders τόπος a two-dimensional surface.[326] Let us demonstrate this fact with the following example. Assuming Aristotle's above definition, an arbitrary void portion's place would be the body immediately surrounding it. Let "X" denote such a portion. It is possible to define X's place, since it is surrounded by plenum. However, this is not true for those smaller void portions which fall within X. Since these later void intervals are either not or only partially surrounded by body, based on Aristotle's definition, it is not possible to define their place. After all, inside the void, there are no bodies which could serve as defining limits and places for anything whatsoever located

[324] For instance, Aristotle argues that void is not necessary for motion, since bodies can also "give way" to each other (see: pg 103-4).
[325] *Physics*, 214a16-19 and 216a23-26.
[326] See also: Furley, 1976, pg 88; Despite the fact that his notion of place already precludes the possibility of void, Aristotle advances several other arguments (especially, under (III,)), with the aim to provide further proof against the existence of empty space.

within. Consequently, a surrounding two-dimensional interpretation of place does not admit of void, and place needs to be three-dimensional to enable the existence of void intervals.

Returning to Aristotle's argument, even though Aristotle rejects the possibility of a three-dimensional τόπος, he assumes void to be such a kind of empty place, and argues against it accordingly. As we have seen, (1,) and (2,) together are enough to reject void. Therefore, at first, I will demonstrate that Aristotle's arguments against three-dimensionally extended space are inconclusive. In other words, he fails to prove (1,). Consequently, we are not compelled to discard the three-dimensional interpretation of place, which admits of the possibility of void.

The first passage (*Physics*, 209a2-7) is only mentioned as one of the "problems" (ἀπορίαι) concerning place, and it is not a genuine argument against a three-dimensionally extended τόπος. It goes as follows: 1, place has "length", "width", and "depth"; 2, a thing which has "length", "width", and "depth" is a body;[327] (1,) and (2,) entail that place is also a body. However, this leads to the absurdity of two bodies (the object and its place) coinciding, which is rejected by Aristotle.[328] Aristotle's solution to this ἀπορία is that, in his theory, τόπος is not three-dimensionally extended, but only a surface. The Atomists would not be disturbed by the argument either, since they reject the idea that "only bodies can be three-dimensionally extended" (2,). They would undoubtedly agree that objects are three-dimensional, but deny that all extensions of this kind fall under the category of material objects. After all, the Epicureans refer to void as ἀναφής φύσις, and distinguish it from plenum on the grounds that, while both are three-dimensionally extended, the former lacks tangible qualities (it is empty), and can be filled by bodies which are tangible. To put it simply, both void and bodies are extensions, but the former is intangible, whereas the latter is tangible.[329] Since void is an extension which is not a body, in the Atomists' system, (2,) does not hold.

[327] See also: *De Caelo*, 268a6-9. In Aristotle's view, a material object is a "magnitude" (μέγεθος), which is extended in three directions (has length, width, and breath).
[328] *Metaphysics*, 1076b1; *De Anima*, 413b17-8.
[329] Lucretius' designation of void as *intactus* (intangible) and body as *tactus* (tangible) brings out this distinction nicely (*De Rerum Natura*, 1.430-9).

The second passage (211b14-29) is an argument, which uses *reductio ad absurdum* to demonstrate the absurd consequences, if place is an independent three-dimensional "extension" (διάστημα). It involves two examples, which I have already described (see: pages 88-90), and, here I will only reiterate their conclusion. Namely, if τόπος was an "independent" extension over and above the bodies,[330] then: a, the process of replacement would result in infinitely many coinciding places; b, the place inside a moving container would overlap with other places, which means that two distinct places would coincide. With respect to his first example (when two bodies replace each other in a container), Aristotle includes his own explanation, which avoids the absurd conclusion of (a,). He argues that the existence of a separate, and independent διάστημα is not required to explain replacement. Instead, the whole process can be described as two bodies, which are "in contact", replacing each other within the vessel (211b18-9). Simplicius adds that, if there is no other body to "come in" (ἀντεισέρχομαι) to replace the departing object, either of the following will occur: a, as is seen in case of the emptying of wineskins, the vessel will "collapse" (συμπίπτω); b, the first body will not leave the container (as fluids in a clepsydra).[331] All in all, the only "entities" involved in the process are the two objects and the container. In other words, there is no separate extension.

Putting aside Aristotle's own explanation of "replacement", the above arguments against place as a three-dimensional extension (209a2-7, 211b14-29) seem to be relevant in the case of the void as well, since it is also regarded as such an extension, capable of receiving objects.[332] Therefore, the absurd conclusions still apply: in its occupied state, τὸ κενὸν would also coincide with the body (the conclusion of 209a2-7), and many places would coincide (see: (a,) and (b,) above). As I indicated above, because they reject its premise, the argument at 209a2-7 is not relevant to the Atomists. The other passage (211b14-29) is no more successful in refuting the void,

[330] In order for these examples to work, it is necessary to assume the extension to be "independent" of the occupying body. In other words, the extension must be able to remain and subsist after the object leaves it. Otherwise, the conclusion, the "overlapping of the places" could not occur.
[331] Simplicius, *On Aristotle Physics*, 573, 5-19.
[332] Aristotle also recognizes the connexion, and refers back to these arguments in the subsequent discussion on void.

and I have already mentioned what possible replies the Atomists could have offered in their defence.

In spite of this, Aristotle applies similar reasoning, when he attacks the possibility of τὸ κενὸν directly (216a26-b16). Unlike the above passages (209a2-7, 211b14-29) which are aimed at the idea of three-dimensionally extended τόπος in general, here Aristotle argues against empty space directly. I have already described the argument (see: pages 89-90), and, just as in the above passages, its conclusion also involves the overlapping of spatial entities: when a cube occupies the supposed void space, its "pure" extension will coincide with the void. Further, since τὸ κενὸν is also characterless, the two extensions will be undistinguishable from each other. Consequently, void is either identical to the body's extension or indistinguishable from it. In either case, its existence is superfluous in describing reality. However, Aristotle's additional claim that "the concurrence of the two extensions (that of the void and the object) would entail that any number of spatial extensions could coincide" is clearly unwarranted (216b10-1). After all, as Sedley points out, it is not possible to conceive of another extension besides the two mentioned, which could occupy the same space. The corresponding void interval functions as the place of the object. However, Aristotle rejects the idea that "place" (in this case, the void) can also have a distinct place for itself.[333] Therefore, no more additional extension can be generated.

Sextus Empiricus also has a version of the argument, where he states that there are three distinct outcomes, when a body occupies a previously empty interval:[334]

1, The void is filled by the object. This alternative is rejected on the grounds that it would entail that the same thing (the void) is "empty" (κενός), and "full" (πλήρης), which Sextus regards absurd. In Aristotle's version, this would result that the corresponding void interval would be indistinguishable from the object's "pure" extension.

[333] Sedley, 1982, pg 186; *Physics*, 210b21-6.
[334] Sextus Empiricus, *adversus mathematicos*, x.21-3.

2, Void is not filled by the object, but it is "replaced" (μεθίσταμαι) by it. Sextus rejects this option by adducing Aristotle's reply that only bodies can be displaced.[335]

3, The coinciding part of void gets destroyed by the occupying object. This alternative is also dismissed: since destruction entails generation, both of which are a form of change, it would mean that void can undergo "alteration" (μεταβολή) and "motion" (κίνησις). However, this is impossible, because the ability to alter and change is exclusive to bodies, and void is not a body.

Having rejected all three alternatives, Sextus concludes that void cannot serve as the place of objects. Can these absurdities be avoided? Let us see what possible replies can be contrived based on the Atomists' theory. With respect to (2,) and (3,), the Atomists would also reject these alternatives on a similar basis. After all, since Epicurus holds that τὸ κενὸν can neither act nor suffer action, it can be neither destroyed, nor moved.[336] Therefore, this leaves us with the only remaining possibility, which is that τὸ κενὸν subsists as the place of the occupying object (1,). In fact, by virtue of being empty or full at different times, the Atomists' void is necessarily subject to the consequences of (1,): I, the void extension would coincide with that of the body; II, the two extensions will be indistinguishable from each other, which means that void would be either identical to the body's extension (II/a), or indistinguishable from it (II/b); III, from (II,), it follows that the void extension is superfluous in describing the existence of the object.

These consequences are not necessarily absurd, and it is possible to solve the problems they suggest, while adhering to the principles of Atomism. As far as (I,) is concerned, the Atomists would see no absurdity in objects coinciding with the corresponding void spaces. This is not really an absurdity, since being "in a place" entails the concurrence of object and its place unless place is such a surrounding surface as in Aristotle. The Atomists would probably also agree to (II/b), since they regard void as a characterless, "pure" extension (as illustrated by the fact that Epicurus refers to it as ἀναφής φύσις (intangible nature)). However, with respect to

[335] See: *Physics*, 216a32-4.
[336] Diogenes Laertius, x.67.

(II/a), even Aristotle would reject it, since both he and the Atomists require place (and void) to be something separable which can be left behind during motion. In other words, void cannot be identical with anything belonging to the body, since the latter abandons and acquires different parts of the void during its movement. In conclusion, in order to maintain their stance, the Atomists need to accept (II/b). However, probably they would interpret the problem differently. After all, Epicurus argues that everything which we perceive (the objects around us) must exist in a material sense.[337] From this, he concludes that these bodies must be located in a place. As we have seen, since the Atomists clearly reject Aristotle's surrounding two-dimensional interpretation, this "place" cannot be anything else but an independently existing three-dimensional extension. Hence, concerning Aristotle's example (see: (1,) above), the Atomists would argue that to be extended spatially, the body needs to be located in a self-subsisting space. In other words, the attribute "extended" is dependent on void, and the latter is prior to the former. Therefore, with respect to (III,), the Atomists would probably regard void not as superfluous, but as absolutely necessary for the object's physical existence.

To sum up, the Atomists would either reject or at least not consider absurd the consequences of (1,). In addition, (1,) is not compelling enough to reject the possibility of a three-dimensional void being filled by objects. Consequently, Aristotle's pertaining passage against void (*Physics*, 216a26-b16), just like the ones which apply a similar reasoning against three-dimensionally extended place (209a2-7, 211b14-29), cannot refute the existence of empty space conclusively, and it is also possible to reply to them through the principles of Atomism. Therefore, let us turn to other arguments, and see whether they are more convincing or not. So far, I have considered arguments which are related to (III/c,) (see: pages 114-5). The remaining ones either presuppose certain kinetic laws (III/b,), or discuss problems involving motion (III/a,). I will follow the order of the *Physics*, and start with the arguments of (III/a,).

[337] *ibid*., x.39-40; See also: pg 105-6.

Here Aristotle discusses problems which result if motion takes place in a void interval. Applying his own distinction between natural and forced movement, he considers them separately: the former at 214b12-215a14; the latter more briefly at 215a14-22. I will begin with analysing the passages discussing natural movement. At first, Aristotle complains that, despite the fact that the proponents of void maintain it, τὸ κενὸν cannot be "responsible" (αἴτιον) for locomotion (214b13-7). In essence, the meaning of the argument depends on how the word αἴτιον is interpreted. If we want to render Aristotle's objection correct, we must regard void as αἴτιον, in so far as it is a "necessary condition" for motion. As we have seen, the Atomists only regarded empty space as a necessary prerequisite for movement. It was αἴτιον in this sense, and did not function as a kind of cause which explains why (or how) objects change place.[338] If we adopt this interpretation, the passage (214b13-7) turns out to be just a reference to a previous argument, in which Aristotle attempts to demonstrate that void is not a necessary condition for motion.[339] However, if Aristotle means that void is αἴτιον by dint of being the "explanatory cause" for locomotion, the objection becomes invalid. After all, the Atomists, in spite of arguing from motion to void, did not attribute such an explanatory role to empty space.[340] In other words, they cannot be asked how the existence of void explains the process of movement.

In the next section, Aristotle demonstrates the absurd consequences resulting from the case where a body is placed in a sufficiently large void interval. These absurdities originate from the fact that natural motion (as Aristotle understands it) is impossible in empty space. Firstly, I will summarize the argument, and then I will elaborate on the parts which require further explanation. In Aristotle's system, all sublunary objects move naturally either down (towards the centre of the Cosmos) or up (towards the circumference). The argument states that since these motions are "different" (διάφορος) from each other, their respective directions (the "up" and "down") must be different as well (215a11-2). However, by virtue of being empty and

[338] In a previous passage (214a24-5), Aristotle also calls void "responsible" (αἴτιον) for movement in so far as it provides the place where the latter could occur. In order to supply the correct meaning, here also αἴτιον must be understood as "necessary condition" and not as an "explanatory cause" for locomotion.

[339] 214a28-32;

[340] See also: Ross, 1936, pg 587-8.

characterless, τὸ κενὸν contains no differences (214b33-15a1).[341] Therefore, "up" and "down" cannot be distinguished in the void, since no differences can exist in it (215a9-10). In consequence of being dependant on the above directions, natural motion is also not possible in empty space. Furthermore, Aristotle divides all movement into "forced" or natural, and the existence of the former depends on that of the latter. Therefore, since natural motion is impossible in the void, there can be no forced one either, and no form of movement can occur in empty space (215a1-6).

Still proceeding from the "characterless" nature of void, Aristotle formulates certain questions about the behaviour of an object within empty space.[342] Firstly, he supposes this object to be stationary, and something which "is placed" within the void space (this is the ἐντεθὲν (or εἰστεθὲν) σῶμα). He asks how this body will move (by nature). Or will it remain motionless (214b21-2)? Where will it go (214b18-9)? After all, its movement needs to have a particular direction, since the object cannot move "into the whole" (εἰς ἅπαν) of the void simultaneously (assuming that it is placed into a sufficiently large emptiness). I will adduce here a similar argument, which considers the case when the object reaching the void is already in motion (215a22-4): if the void, which "yields" (ὑπείκω) to the moving body, is uniform in all directions, the body "will move in every way" (πάντῃ οἰσθήσεται), which is similar to the case where it "moves into the whole (of void)" mentioned above. All in all, due to the above uncertainties surrounding the object's natural motion, instead of setting off in a given direction, Aristotle seems to regard it as more plausible that the object "stays still" (ἠρεμέω).

One of the possible reasons why Aristotle stresses this alternative (that the body remains in place), is that he wishes to demonstrate that those who argue from the existence of motion to that of void (for instance, the Atomists) are wrong in attributing such a role to τὸ κενὸν. Instead, the case appears to be the opposite, since nothing moves in empty space. That Aristotle has something similar in mind is clearly

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[341] The additional claim that "there can be no 'up', 'down', or 'centre' within the infinite" (215a8-9), is not essential to the present argument against void. Moreover, it is not even valid, since as I have already mentioned in chapter II (pg 58-9), Epicurus manages to define an "up" and "down" for his infinite universe.

[342] The following questions all refer to the object's **natural** motion within the void.

alluded to by 214b28-31: rather than being necessary for motion, by making objects remain motionless, empty space renders movement impossible. Another reason is mentioned explicitly by Aristotle. Namely, since empty space contains no distinctions, why would an object (naturally) move in one direction rather than in another (214b33-4)? Therefore, it appears more plausible that it would not move at all.

So far we have summarized Aristotle's objections, which consider problems arising when an object is placed within empty space (214b12-215a14). Can these objections convince us to reject the possibility of void space? I believe they cannot, and, now, I will consider what the problems are with Aristotle's argument. The main reason why Aristotle asks the above questions originates from his belief in the following: the absolute directions of "up" and "down" cannot be distinguished in the void, due to the latter's characterlessness (P). However, as I have shown, these directions do not exist in an absolute sense in our universe.[343] Also, there is no universal centre or circumference (the defining points of the above directions in Aristotle), and it is only the force of gravity which accounts for motions called natural by Aristotle. Since (P) argues from the existence of these absolute directions, it has no validity outside the Aristotelian system.

Even if we accept Aristotle's requirement for the establishment of these absolute directions, (P) holds neither if the emptiness is regarded as finite nor if it is taken to be infinite in extent. In the former case, it goes against experience to assume that the naturally falling body would lose its orientation when traversing a finite void interval (that it would cease moving or would express erratic behaviour).[344] After all, supposing this empty section to be in a finite universe (like that of Aristotle), the directions governing natural movement could still be ascertained by the overall structure of the universe (by its centre and circumference). What is more, these directions would still exist even if we "empty" the whole Aristotelian Cosmos of matter, only leaving our "test particle" behind to observe its natural movement. Furley suggests that the reason why Aristotle would still regard such motion through a void interval as problematic lies in the following: Aristotle requires that the

[343] See: chapter II, pg 54.
[344] Sorabji, 1988, pg 143.

naturally falling body should always be “in a place”.[345] However, this is not possible in void, where there is no surrounding body which could serve as a place for the falling object. This follows from Aristotle’s definition of an object’s place as the “limits of the surrounding body”. However, as I have already discussed, the *Physics*’ notion of place raises more problems than it solves, and neither we nor the Atomists are compelled to accept it. With respect to the latter case (when the universe is infinite in extent), I have already discussed it in chapter II, where we have seen how Epicurus defined the directions of “up” and “down” even in an infinite universe. Therefore, (P) does not hold in this case either.

All in all, Aristotle’s argument at 214b12-215a14, which focuses on the natural behaviour of objects placed within an arbitrary void space, proves inconclusive both if the space in question is limited, and if it is unlimited in extent. So far, we have considered the part of the argument which focuses on natural movement. Now, let us turn to the other part which considers forced motion (215a14-22). Since the second half of the passage (a19-22) expresses an objection which rests on the same principle as those I have just considered, I will start with it. Here, Aristotle assumes a scenario where an object, which has already been put into motion by an external agent (this is what κινήθεν denotes),[346] enters an empty interval (let us denote this scenario with “X”). Aristotle asks the proponents of void why this body would stop somewhere. Since there are no distinctions within the void, why would it stop at one place rather than at another? Therefore, Aristotle concludes that the object will either remain still or continue moving towards infinity (215a20-21). Although the presence of ὥστε (therefore) at the beginning indicates that the subject of the sentence is still the “moved” body considered in the preceding lines, the option that the object “remains still” (ἠρεμέω) probably refers to something which is not in motion, but simply “placed into” the void (this is the kind of object considered in the previous argument (214b12-215a14)). In fact, as we have seen above, there also Aristotle reaches a similar conclusion: the object placed into the void would rather remain motionless than move in a given direction. Consequently, according to

[345] Furley, 1976, pg 94-5.
[346] The word κινήθεν (the “moved”) refers back to τά ῥιπτούμενα (things that are thrown) mentioned at 215a14. In a general sense, these are the bodies undergoing forced movement.

Aristotle, the only plausible alternative for the already moving body is to continue its motion *ad infinitum* "unless something stronger obstructs it" (a21-2).[347] Since in empty space this is unimaginable, the object will move into the infinite as long as its course is within the void.

To sum up, in the argument at 215a19-22, Aristotle asks why a moving body would stop in the void. Since he believes that there is no reason for it to halt anywhere, he concludes that it must travel on endlessly, which Aristotle regards as absurd. This follows from Aristotle's belief that locomotion (or any kind of change), which cannot be completed (traversing an infinite distance falls under this category), cannot exist in the first place.[348] This means that not only are completed infinite motions impossible, but we cannot even commence a movement which would traverse an infinite distance. Although Aristotle might be right with respect to completed infinite movements, we have no reason to deny the possibility of a kind of infinite motion which could be started but never finished. Just as in the case of counting natural numbers, we can continue the action for as long as we wish. However, we can never complete it (count all the numbers). With respect to Atomism, we know that Epicurus did not regard such a "potentially" infinite motion as impossible, since he held that all atoms move endlessly (in straight lines with equal speeds) in the infinite void until they collide with other atoms.[349] Therefore, what Aristotle regarded as absurd, for Epicurus, was the valid explanation.

However, there are further problems with the argument when a finite empty space is being traversed. For instance, just as in the case of the naturally falling stone (see: page 123), it seems strange to assume that an object undergoing forced movement (for instance, a thrown projectile) would lose its orientation when crossing a finite empty space. Why couldn't it maintain its speed and direction throughout a 10 metre wide void section? Similarly, let us suppose a motion where a thrown projectile starts off in a plenum (X), crosses a 10 metre void (Y), then hits the ground after being slowed down by another plenum (X). This seems to be perfectly realizable, if the

[347] See also: Hussey, 1983, pg 130.
[348] *Physics*, 241b2-12.
[349] Diogenes Laertius, x.43, 61.

existence of void is presupposed. However, in Aristotle's view, the entirety of this motion is impossible: the projectile cannot cross Y, because that would be a "potentially" infinite motion, which, as we have seen above, is rejected by Aristotle. Or does Aristotle reason only against the possibility of infinite empty space being traversed (in which case, the above objection loses its relevance)? If so, he does not mention it explicitly. In any case, his argument at 215a19-22 is inconclusive both against a limited and against an unlimited expanse of void.

After dismissing these additional objections against forced motion in a void, the only remaining reason for the impossibility of such a movement comes from Aristotle's evidently fallacious theory about forced movement.[350] The discussed passage (215a14-9) only mentions a few words about it: in the case of "thrown objects" (τὰ ῥιπτούμενα), after the projectile is no longer in contact with the original mover, the motion is maintained through either "mutual replacement" (ἀντιπερίστασις), or by the intervening air pushing the object onward.[351] The latter alternative is more fully explained elsewhere by Aristotle (266b27-267b8). He argues that the motion must be sustained by a succession of movers, since a moving object always needs a mover continuously in contact with it.[352] To achieve this, in a manner left unexplained, the original mover (the thrower of the projectile) both moves the intervening air, and imparts the power of "being a mover" to it. Then, the intervening air becomes the new mover sustaining the motion. This way the projectile keeps moving even after it is no longer in contact with the thrower. The important point is that the motion of the projectile requires a mover continuously in contact with the thrown object. Such a motion is obviously impossible in void where there is no external body to fulfil this function. However, Aristotle's theory is wrong. As Newton's first law describes, due

[350] Forced movements can be divided into two categories: 1, when the mover remains in contact with the object throughout the whole process (for instance, a horse which pulls a cart); 2, when the object and mover become separated (in case of a thrown projectile). As Simplicius rightly observes, in this argument, Aristotle only illustrates the impossibility of the latter kind (2,) in void (*On Aristotle Physics*, 668, 13-6).

[351] The words "ὥσπερ ἔνιοί φασιν" (as some say) indicate that the explanation by ἀντιπερίστασις is not Aristotle's own. Simplicius expounds how the motion of the projectile can be explained by ἀντιπερίστασις, and mentions Plato's *Timaeus* (59a) as a reference to a similar theory of "mutual replacement" (*On Aristotle Physics*, 668, 25-69, 2).

[352] This follows from Aristotle' theory that, except for self-movers (for instance, animals), a moving object needs to be moved by something else, which is its moving cause. The argument for this view is presented in *Physics* (book VIII, chapter 4).

to inertia, the projectile would continue to move even if there were nothing to push it onwards. Consequently, since no external agent is required to sustain the motion, the argument fails, and neither we nor the Atomists are compelled to accept that forced motions are impossible in empty space.

As we have seen, Aristotle's general objections against motion in void (see: (III/a) on page 114) are not convincing enough to make us doubt the existence of empty space. Neither natural nor forced movement seems to be impossible in void, and the arguments are even less successful, if the relevant space is regarded as finite in extent. Let us proceed, and analyse those arguments which attempt to refute empty space by demonstrating its incongruity with certain laws of motion, presupposed by Aristotle (III/b). Two arguments fall under this section, both of which apply *reductio ad absurdum* to show the impossibility of void. The first one considers the motion of a given body through mediums with different density (215a29-216a13). The second one compares bodies of differing weight moving through the same medium (216a13-21).[353] Since neither of these arguments can refute the existence of void conclusively, I will only provide an outline of them. Then, I will mention some problems which render Aristotle's reasoning implausible.

In the first argument (215a29-216a13), the same body traverses mediums with differing density. Before commencing the analysis, let us make some additional assumptions, which are not present in the original argument, in order to facilitate understanding. Firstly, let us assume that a single constant force (for instance, **G**) acts upon the object in all instances. Secondly, let us regard the speeds reached in the various mediums as "terminal velocities".[354] These assumptions will not harm Aristotle's reasoning. The argument rests on the idea that the thicker medium offers greater resistance, because of which the same object will proceed in it more slowly than in a medium with smaller density (215a30-31).[355] So far the argument seems

[353] The division of the passage into two arguments is introduced beforehand at 215a25-9.

[354] "Terminal velocity" is the highest attainable speed of a given object in a given medium. There is no evidence that Aristotle regarded the different speeds mentioned in the argument as terminal velocities corresponding to different media (Drabkin, 1938, pg 77-8; Hussey, 1983, pg 131). In this argument, I will use "speed" and "terminal velocity" interchangeably.

[355] Aristotle uses the adjectives παχύς (thick), and λεπτός (fine in texture) in their comparative forms to indicate the relative density of a given medium.

sound, and this kind of general statement could be derived from relatively simple observations.[356] However, Aristotle goes further and assumes that the terminal velocity of a given body is in inverse proportion to the density of the medium being traversed (215b4-12). Based on this correlation, he produces two demonstrations which can be rendered as equations. These become invalid if we substitute void in them:

$$\frac{A}{B} = \frac{D}{C}$$

Let us suppose that "E" and "F" are homogenous mediums, which have the same length and are crossed by the same object. In this case, "A" and "B" are the speeds in E and F respectively. "C" denotes the density of E, whereas "D" denotes that of F. The density of empty space is "0". However, 0 cannot be substituted into the above equation, either because it cannot be a dividend, or it would mean that the speeds (A and B) stand in no relation to one another, or alternatively the speed in void would be infinite (if D=0, B becomes infinite). As Aristotle highlights, the above inverse proportionality (between velocity and density of medium) does not work with void, since its density is 0, and zero can stand in no relation to a finite quantity (or number).[357] In other words, there can be no ratio in the form of X/Y where both X and Y can assume "0".

With the second equation, Aristotle illustrates that empty space can stand in the same proportion to plenum as plenum to another plenum, which he regards as absurd. Let "F" denote void medium, while "D" denotes that of homogenous plenum, in both of which equal length is traversed. Further, the same body crossed F in time "H", and D in time "E". If the inverse proportionality (between velocity and density of

[356] In fact, Aristotle introduces both this and the subsequent argument with the word "we see" (ὁρῶμεν) (215a25, and 216a13) which suggests that their basic underlying assumptions are derived from experience (for instance, that the thicker a medium, the slower its traverse). In this respect, these arguments can be considered "scientific" where the propositions are based on and in accordance with empirical observations. For more information about scientific and dialectic reasoning in Aristotle, see: chapter II, pg 36-7.
[357] 215b12-3 and b20.

medium) is assumed, the corresponding times will be in direct proportion to the medium:

$$\frac{H}{E} = \frac{density\ of\ F}{density\ of\ D}$$

Since Aristotle has just demonstrated that zero cannot stand in relation to a finite number, he assumes that H (the time to cross the void) cannot be 0, but must be a determinate positive number.[358] However, in this case, the void space (F) can be substituted with a plenum ("Z") whose density stands in the same relation to that of D as H to E, and the object will traverse Z in the same time as it would cross the void which is impossible (216a3-7). After all, Z is supposed to be a plenum with resistance, whereas void offers no resistance. Consequently, if motion takes time in void, these absurdities follow. On the other hand, it cannot take no time either, since 0 cannot stand in relation to a finite number (in this case, the duration of movement in plenum). In either case, by virtue of having zero density, empty space is incongruous with the inverse proportionality (between velocity and density of medium) established above by Aristotle.

However, the assumption underlying the whole of Aristotle's reasoning is faulty, because, in reality, there is no simple inverse proportion between speed and the density of the corresponding medium.[359] Since the assumption (the premise) does not hold, the argument (215a29-216a13) loses its force, and cannot refute the existence of void. In addition, as we have seen, due to the zero density of void, this proportionality would entail that movement through empty space takes no time, and the velocity is infinite. However, under ideal conditions, all objects regardless of their characteristics fall with equal (and finite) speeds in void.[360] This brings us to Aristotle's next argument (216a13-21), and the Atomists' reply to it.

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[358] 215b12-3 and b20; See also: Simplicius, *On Aristotle Physics*, 674, 21-3.
[359] It would require too much space to expound the modern physical explanation of the force of drag exerted by the medium in which the movement takes place. For the ways in which Aristotle's theory is wrong, see: Drabkin, 1938, pg 66-9.
[360] Drabkin, 1938, pg 67; Ross, 1936, pg 591.

Here, Aristotle considers the case where the medium is kept constant, and certain qualities of the bodies in question are being varied in order to effect differences in speed. Firstly, Aristotle states that the object's speed when traversing a medium varies in accordance with its "preponderance (ῥοπή) of weight or lightness" (216a13-15).[361] As Simplicius explains, this means that from two objects of the same shape, the heavier will fall faster, and the ratio of the speeds will correspond to the ratio of weight.[362] For instance, a 2 kg sphere will fall twice as fast in the same medium as a 1 kg sphere. Secondly, the object's shape (σχῆμα) also affects its velocity. The effect of both factors can be attributed to their influence on the ability of the moving body to "divide" (διαιρέω) the medium. For the heavier will divide the medium more easily by virtue of having greater "strength" (ἰσχύς), and the shape also affects the force of drag exerted by the medium (216a18-20). Aristotle argues that neither weight nor shape has any influence in empty space, since their effect depends on the force of drag which is only present in plenum. Consequently, all objects would travel equally fast in void, a possibility which he regards as absurd (216a20-21).

However, as has been said, if ideal conditions are supposed, all bodies will fall with equal (and finite) speeds in a vacuum. In this respect, the Epicureans are correct when they attribute an uniform (and finite) velocity to the atoms in their downwards fall.[363] Lucretius' argument reflects his intention not only to prove his case but to counter Aristotle's objections as well. He argues that by virtue of their resistance, plenums (such as air or water) contribute to the differences in the speed, and the heavier object would indeed fall faster in the same medium (Aristotle's argument). However, the void, by virtue of being empty of matter, offers no resistance whatsoever. Therefore, it does not influence the natural downward movement of bodies which in turn fall with equal speeds in void. Since the conclusion of Aristotle's argument (that there are no differences in the speed of fall in void) is not an absurdity, but the correct

[361] For the sake of simplicity, let us restrict our scope to the natural fall of heavy objects. This will not affect the argument.

[362] Simplicius, *On Aristotle Physics*, 678, 19-22, 678, 31-79, 3; Just as in the previous argument, it facilitates understanding, if we regard speed as terminal velocity.

[363] Diogenes Laertius, x.61; Lucretius, *De Rerum Natura*, 2.225-239.

explanation, and the argument is intended as a *reductio ad absurdum*, the whole reasoning (216a13-21) is rendered useless.

This concludes my analysis of Aristotle's arguments against void. As we have seen, each argument is beset by certain problems which render them ineffective both in general, and against the Atomists. In the next section, I will summarize the main reasons which cause Aristotle's failure in refuting empty space. Further, I will include a summary of the conclusions arrived at in this part of my analysis, which will show that, although neither side can provide an unshakeable proof for or against the existence of void, the Atomists seem to achieve more in this respect than Aristotle.

III.5 Conclusion

With respect to the arguments for void space, as we have seen, there is only one group of arguments which can be attributed to the Atomists with reasonable certainty. These are empirical arguments which reason from the observed existence of motion to that of empty space (they argue that empty space is necessary for movement to take place). Aristotle argues against them by demonstrating that void is not necessary for movement since objects can also "give way to each other" (ὑπεξιέναι ἀλλήλοις). As we have seen, whether his attempt of refutation is successful or not depends on the question of divisibility.[364] Nonetheless, irrespective of the validity of these "from motion to void arguments", the Epicurean version (Diog. L., x.39-40; *De Rerum Natura*, 1.426-7) is at least partly successful: it manages to prove the existence of the occupied parts of void space.[365] However, the argument for the existence of its empty parts is undermined by Aristotle's above alternative explanation, and cannot be accepted without qualification.

[364] See: pg 104-5. The Atomists and Aristotle had opposing views about the divisibility of matter (and space), and I will consider this question in more detail in the subsequent chapter.
[365] Remember that we have rejected Aristotle's two-dimensional notion of place, and concluded that the only remaining way to fulfil the requirement of the Epicurean argument (that bodies need some place where they can exists in a material sense) is to assume the existence of a separate three-dimensional receptive space (the occupied parts of void). For the analysis, see: pg 105-112.

Turning to the other side, overall, Aristotle's attempt to refute the existence of void proved to be unsuccessful. As we have seen, the *Physics'* surrounding, two-dimensional view of place already precludes the existence of empty space. However, the arguments which Aristotle adduces for it are inconclusive, and we have seen how the notion itself that place is a "two-dimensional, surrounding surface" raises certain difficulties. Putting aside these considerations, each of Aristotle's arguments, aimed directly against the possibility of void, is beset by certain problems, which renders them unconvincing. The majority of them are a *reductio ad absurdum* which result in an unacceptable conclusion, if the existence of void is presupposed. By and large, there are two kinds of problems with these arguments. Firstly, the more common type is when Aristotle presupposes certain notions (or laws) which are either incorrect or not necessarily true. Since these presuppositions feature as premises for the arguments, through their rejection the arguments also fail. We have already encountered some of these when discussing Aristotle's attempted refutations with respect to the infiniteness of space. For instance, neither we nor the Atomists are compelled to accept the Aristotelian laws of natural motion (and places), which are utilised by the arguments under III/a on page 114, and, as has been said, ascertaining their truth-value would require an independent investigation. In addition, there are those suppositions, such as the kinetic laws underlying the arguments under III/b,[366] which are evidently incorrect. With respect to these arguments, by and large, the reasoning is logically correct, but the conclusions are invalidated by the fallacious premises.

Secondly, there is a type of fault which originates from the fact that the argument itself is a *reductio ad absurdum*. Here, the conclusion, which is supposed to be absurd for the argument to work, is, in reality, the correct explanation of the phenomena being discussed.[367] It is needless to say that a *reductio ad absurdum*, where the conclusion itself is correct, cannot be valid. In a somewhat different case, the supposedly absurd conclusion is not necessarily incorrect, but only absurd in the eyes

[366] The proportions between the speed of fall and the medium, and Aristotle's fallacious explanation of forced movement.
[367] For the details, see: pg 124-5.

of the one producing the argument.[368] Since, in this case, the conclusion is not absurd (neither in general nor for the Atomists), these arguments also fail. All in all, due to the fact that each are invalidated by one or more of the above mentioned problems, none of Aristotle's arguments against the existence of void space seems convincing enough. Therefore, if we compare the two sides, although neither can provide an unshakeable proof for or against the existence of void, in proving the existence of the occupied parts of the void, the Atomists seem to achieve more in this respect than Aristotle. In this respect, our analysis yielded a similar result as in the previous chapter, where one of the arguments used by the Atomists for the infiniteness of the universe (that of Archytas) proved to be more convincing (albeit not valid without qualification) than any of Aristotle's counter-arguments.

[368] See: Sextus' argument on pages 118-20.

Chapter IV

Is there a limit to the division of matter?

In the present chapter, I will consider the arguments of Aristotle and the Atomists relating to the divisibility of matter. Just as with respect to the topics of the previous chapters, concerning divisibility the Atomists and Aristotle adopted opposite views. The latter regarded the stuff of all material objects as divisible *ad infinitum*, a view which was rejected by the Atomists who argued that all such objects are constituted of primary particles (the atoms), which by virtue of being indivisible themselves, serve as a lower limit to the division of physical matter. In view of this unique characteristic of the primary bodies, they are often referred to as "uncuttable" (ἄτομος), and "indivisible" (ἀδιαίρετος).[369] As we shall see, the postulation of atoms features as a final conclusion within the arguments by which the Atomists attempt to rebut the infinite divisibility of matter. First, I will analyse these arguments. Then, I will consider the opposing party, and see what reasons Aristotle adduces for infinite divisibility. As we have seen, the question whether Aristotle's refutation of the Atomists' chief argument for void (the so called "from motion to void" argument) is successful or not depends on the divisibility of matter. After all, his alternative explanation to movement, by which he refutes the Atomists, inevitably leads to the generation of void interstices (between the moving objects) unless their matter is divisible *ad infinitum* (in a physical sense).[370] Therefore, in order to decide this question, my subsequent analysis will be focused on arguments concerning the divisibility of physical matter.

[369] There are various other peculiar characteristics of the atoms, by virtue of which they differ from ordinary, compound bodies. In this respect, there are slight variations between the theories of Epicurus (and Lucretius), and those of the early Atomists. Even their views on the divisibility of atoms admit of some difference, a question which I will return to later on. For more information on the characteristics of atoms, see: Bailey, 1928, pg 76-90, 123-38, 275-99; Barnes, 1982, 40-50; Furley, 1987, 122-31.

[370] For the original discussion, see: chapter III, pg 104-5.

However, for a proper analysis we also need to clarify what we should understand under the word "(in)divisible" when looking at the relevant arguments. Therefore, I will start with ascertaining the various senses of "(in)divisibility" which come into question, and determine the differences between Aristotle and the Atomists with respect to their interpretation of this word. By and large, when considering either Aristotle or the Atomists, modern scholars distinguish between "physical" and "theoretical" divisibility. However, in my eyes, these two senses of divisibility are not sufficiently straightforward to be used without further elucidation. In spite of their inherent ambiguity, when using these expressions, most modern scholars either omit to furnish the required definitions or their definitions are too inexact to be applicable.[371] One of the underlying reasons is that neither Aristotle nor the Atomists clarifies what exactly "being (in)divisible" means for them, a fact which impels modern scholars to come up with their own definitions. In view of the ambiguity of these expressions, I will attempt to furnish a sufficiently exact interpretation of them, which I will consistently apply in my analysis of the relevant arguments. While doing so, I will neither argue for the idea that Aristotle and the Atomists defined divisibility in the same manner, nor state that these are the only viable definitions. Rather, I will furnish potential definitions with which it is possible to properly interpret the relevant arguments.

The meaning of physical divisibility is relatively straightforward. I define it with a "bi-conditional" statement ("$A \equiv B$"). The definition is as follows: I will call X physically divisible, if and only if there is a conceivable physical action with which X can be divided; whereas X is physically indivisible, if there is no such action. This kind of division is actualized only if X has been separated into parts by a spatial interval.[372] Furthermore, the physical nature of this concept demands that, in order to be divisible in this sense, X must be a material object. There is a great deal more ambiguity surrounding the meaning of theoretical indivisibility. For instance, taking Furley's definition, "an object is theoretically divisible if parts can be distinguished

[371] For the original idea and the pertaining analysis of the relevant scholarly discussions, see: Makin, 1989.
[372] For a similar definition of physical divisibility, see: Furley, 1967, pg 4; Taylor, 1999, (ii) on pg 165.

within it by the mind."[373] However, as Makin observes, it is unclear what exactly such parts are, and what kind of mental action should be used to draw a distinction between them.[374]

One of the underlying problems is the fact that the meaning of the adjective, "theoretical" is unclarified, a fact which renders the kind of divisibility associated with it ambiguous as well. After all, we can ask questions like: what does theoretical mean in this context? According to what theory is something divisible? The latter question might be answered by furnishing analogous concepts, such as mathematical or logical divisibility where the adjectives themselves possess a somewhat more definite meaning, a fact which enables the construction of more exact definitions. In fact, some scholars indeed attempted to shed more light on "theoretical divisibility" by dint of the definitions of such analogous senses of divisibility.[375] In the same vein, when determining my own interpretation of theoretical divisibility, I will also rely on a kindred concept. In other words, rather than being "theoretical", my definition will resemble that of mathematical or geometrical divisibility. I will explain my reasons for doing so. However, beforehand, let us have a look at the definition itself.

I will regard X as theoretically divisible *ad infinitum*, if it is possible that when considering its extension in abstraction, I can allocate any number of (distinct) points on it, and between any two of these allocated points I can repeat this action indefinitely. If I am unable to do this, X is not divisible in this sense. Obviously, just as in case of physical divisibility, since it is a "bi-conditional" statement (in the form of "$A \equiv B$"), the reverse of the above also holds true. I will illustrate the meaning of the above definition through some examples. For instance, let X be a line with an arbitrary length. In this case, it is possible to allocate a point (or points) on it by which I can always divide X into two or more parts, and I can do the same with the resulting sections as well. Therefore, what is theoretically divisible is infinitely divisible at the same time. The definition also holds true of surfaces and three-dimensional extensions. The only difference is that in their case, one divides along not points, but

[373] Furley, 1967, pg 4.
[374] Makin, 1989, pg 128-9.
[375] For instance: Baldes, 1978, the three kinds of "mental division" on page 3; Barnes, 1982, pg 54-5.

lines and surfaces respectively. In other words, one divides a surface by allocating a line on it, and the latter is theoretically divisible as described above. In reality, any number of distinct lines can be marked out on a surface, from which it follows that surfaces are theoretically divisible as well. The situation is similar with regards to three-dimensional extensions. In their case, one can define any number of distinct surfaces which themselves are theoretically divisible as shown above. In this way, one can demonstrate the theoretical divisibility of all forms of geometrical extension from that of lines. However, X's domain is not limited to geometrical extensions and material objects. In fact, my definition applies to all kinds of continuum. For instance, even a stretch of time is divisible in this sense, because I can allocate any number of points (of time) on it.[376]

My reasons for interpreting theoretical divisibility in this manner are threefold. Firstly, unlike Furley's definition, as the above examples indicate, mine possesses the necessary degree of exactness which renders it usable. Secondly, my definition has a relatively broad sense. For instance, as Baldes explains concerning his tripartite "mental division" (see: note 375), if something is divisible "conceptually" or "elementally", it is so mathematically. However, the converse does not hold. Having a sufficiently broad sense is desirable, since it abates the danger of excluding arguments, which might have been relevant otherwise, on the grounds that they do not relate to theoretical divisibility. Thirdly, as my analysis will show, this interpretation of theoretical divisibility is suitable for working with the relevant arguments of Aristotle and the Atomists. In view of these reasons, whenever I call something theoretically (in)divisible in the subsequent analysis, I will refer to the above definition.

As we have seen, the domain of physical divisibility is the world of material objects, all of which are spatially extended. Consequently, since all such extensions are theoretically divisible (see: above), physical divisibility entails its theoretical equivalent. Obviously, this relation entails that something, which is not theoretically divisible, cannot be separated physically either. However, this relation does not apply

[376] For similar definitions, see: Baldes' "mathematical divisibility", and Barnes' "geometrical divisibility".

in the case of indivisibility, since it is possible to conceive of a physically indivisible (material) object, which, by virtue of its magnitude, is still theoretically divisible.[377] From a different perspective, it can be said that, although physical divisibility entails theoretical, the converse does not hold. After all, we can easily think of certain theoretically divisible extensions (for instance, the objects of geometry) which, by virtue of being incorporeal, fall outside of the domain of physical divisibility.

After discussing the relationship between theoretical and physical divisibility, we ought to decide whether the arguments of Aristotle and the Atomists concern both kinds of divisibility, or only one of them, and, if the latter proves to be the case, which one. With respect to the Atomists, the question at issue is whether they regard their atoms as both theoretically and physically indivisible, or only physically.[378] At first, it must be noted that, concerning the divisibility of the atoms, the views of the early Atomists, and that of Epicurus (and Lucretius) differ considerably. Therefore, I will discuss their views separately. At present, I will only consider the early Atomists, and I will talk more about Epicurus' primary bodies later on. Here, I just mention that Epicurus (and Lucretius) regarded atoms as physically uncuttable, yet theoretically divisible; whereas, the early Atomists did not make such a clear-cut distinction between the two kinds of divisibility in connexion with their primary bodies.

There is an on-going debate between scholars concerning what kind of divisibility the early Atomists ascribed to their primary bodies, and it would require a separate work of similar extent to provide an exhaustive analysis of this highly controversial question. Therefore, I will only summarize the alternative standpoints, based on which I will draw some conclusions which will be relevant to my upcoming analysis of the arguments. By and large, the different views of scholars can be classified as follows: 1, Democritus and Leucippus regarded the atoms as physically indivisible, but theoretically divisible; 2, they believed the atoms to be both theoretically and physically indivisible; 3, based on the available evidence, it is not possible to decide

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[377] An example for such an object would be Epicurus' atoms which are physically unsplittable, yet possess theoretical parts. I will say more about the atoms of Epicurus and Lucretius later on.

[378] Remember that physical divisibility invariably entails its theoretical equivalent, but the converse is not true.

between (1,) and (2,).[379] It is argued that a possible reason for this uncertainty lies in the fact that neither Aristotle nor the early Atomists recognized the distinction between theoretical and physical divisibility.[380] I will not discuss this question in detail. Nonetheless, with respect to Aristotle's arguments, I will touch upon this question, and suggest that Aristotle could have indeed been unaware of the distinction between the two kinds of divisibility mentioned above.

As confirmed by the sources listed under notes 373-5, the fact that the early Atomists believed their atoms to be physically unsplittable is undisputed. However, the question whether, at the same time, they rejected theoretical indivisibility (1,), or regarded atoms as both physically and theoretically indivisible (2,), cannot be decided. Therefore, when looking at the arguments of Democritus and Leucippus, I will limit my scope to physical indivisibility, and examine their validity in this respect. In doing so, I will show that, within these arguments, there is no indication (neither explicit, nor implicit) that they concern theoretical divisibility exclusively.[381] In addition, my approach will prove that it is perfectly possible to regard the divisibility in question as physical without depriving the particular argument of its force. With respect to the Epicureans, I will follow the same approach, since their atoms were only physically indivisible.

The fact that my focus is on physical divisibility will have a considerable impact on my treatment of the Aristotelian corpus as well. As we shall see, Aristotle's arguments for infinite divisibility work only if the divisibility in question is theoretical. Consequently, these arguments are ineffective against the Atomists in so far as the physical indivisibility of the atoms is at issue. Therefore, in my analysis, I will not endeavour to determine the validity of these arguments. Instead, in each case, I will demonstrate that the underlying reasoning is ineffectual against an atom which is only physically indivisible. Understandably, this feature of Aristotle's arguments will

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[379] Some relevant literature: concerning (1,), see: Baldes, 1978; Barnes, 1982, pg 50-8; Burnet, 1930, pg 336; Heath, 1921, pg 181; Kirk, Raven, Schofield, 1983, pg 415; Makin, 1989; concerning (2,), see: Furley, 1967, pg 79-103; Guthrie, 1965, pg 503-7; concerning (3,), see: Sorabji, 1983, pg 354-7; Taylor, 1999, pg 164-71.

[380] This seems to be the reason why Sorabji and Taylor endorse (3,). In contrast, although Furley (1967, pg 94) also acknowledges this fact, he still endorses (2,).

[381] Here, I am not referring to the body of evidence which is adduced in favour of (2,). Instead, these are arguments which are directly aimed at proving the finite divisibility of matter.

lead to his failure to refute the existence of physically unsplittable primary bodies. Nevertheless, this will not result in the victory of the Atomists, since my analysis will reveal that none of their arguments manages to prove the finite divisibility of matter. Up to this point, I have distinguished and defined two senses of being divisible, and discussed how these two senses relate to the arguments of Aristotle and the early Atomists. In addition, I have identified my subject matter, and explained the reasons why I will limit my scope to the physical divisibility of matter. Presently, I will turn to the actual arguments either for or against the infinite divisibility of matter.

IV.1 Arguments against the infinite divisibility of matter

I will start my analysis with the arguments of the Atomists who held that all material objects consist of particles which are indivisible (at least physically). Before turning directly to these arguments, we must say something about their origin. Here, I am not referring to the origins of Atomism in general. Instead, I am considering ideas (or thoughts) which the Atomists borrowed from previous thinkers (or, at least this is what the evidence suggests), and integrated into their own arguments for the finite divisibility of matter. In order to unravel the origins of these ideas, we must reach back to the arguments of the Eleatics (especially, that of Zeno). The fact that the Atomists knew of, and reacted to Eleatic notions is undisputed.[382] In this respect, I am only concerned with the arguments of Zeno. As my analysis will reveal, the Atomists appear to have borrowed elements from Zeno's reasoning, and integrated these into their own arguments against the infinite divisibility of matter.

Therefore, let us look at some of Zeno's arguments which bear some relevance to our inquiry. Although little is known about his life, it is accepted by most scholars that Zeno was a younger contemporary and follower of Parmenides. According to tradition, he produced numerous arguments, from which only a handful are

[382] For instance, see: Burnet, 1930, pg 334; Furley, 1967, pg 81. For the idea that the Atomists borrowed elements from Zeno's arguments, see: Bailey, 1928, pg 72-3; Barnes, 1982, 52; Furley, 1967, pg 84-5; Taylor, 1999, pg 164.

preserved.[383] Although Plato states that these arguments are designed to defend Eleatic "Monism", the exact purpose of Zeno's paradoxes remains uncertain.[384] Nevertheless, Plato seems to be correct in so far as the extant arguments indeed attack the notion that there are many things in existence, a notion which is at variance with the views of Parmenides who argued that reality is a "homogenous one", and indivisible.[385] In general, Zeno's method was to presuppose plurality, and show the absurd consequences of such a presupposition. Here, I am only concerned with those arguments which presuppose the infinite divisibility of matter, and conclude in various absurdities in case this supposition holds true. I will describe these briefly (without evaluating them); then, in my subsequent analysis of the Atomists' arguments, I will refer back to them whenever a particular reasoning of the Atomists appears to rely on inferences contained within these arguments. I will begin by describing two arguments both of which are preserved by Simplicius.

The first one (*On Aristotle Physics*, 139, 26-140, 6) is attributed to either Parmenides or Zeno.[386] The argument is designed to demonstrate the indivisibility of the Eleatic "being" (τὸ ὄν) by means of *reductio ad absurdum*. It presupposes the infinite divisibility of τὸ ὄν, and concludes in absurdities. The reasoning goes as follows: if being is divisible, and we carry it out via "bisection" (δῐχότομος), this process can be repeated *ad infinitum* (139, 27-9). From this, three alternative results are envisaged:

1. If the resulting parts have magnitude, these can still be further divided. Therefore, the initial premise does not hold, since the process of division is not completed (140, 4-5).
2. An infinite number (probably due to the fact that the process of bisection is also infinite) of "smallest and indivisible" (ἐλάχιστα καὶ ἄτομα) magnitudes

[383] See: under Zeno in Diels-Kranz (A15). Plato, *Parmenides*, 127A-128E; For a good collection of the extant arguments (with translation and commentary), see: Lee, 1936.
[384] Plato, *Parmenides*, 128C-D; Barnes argues that, although Zeno's paradoxes are indeed directed against a pluraistic world picture, they cannot be regarded as specifically defending Eleatic "Monism" (1982, pg 233-4).
[385] For more on the views of the Eleatics, see: chapter III, pg 80-1. For more on Zeno's paradoxes (including discussions about their probable purpose), see: Barnes, 1979, 231-95; Furley, 1967, pg 63-78; Sorabji, 1983, 321-335.
[386] It is more probable that the argument belongs to Zeno. This is also confirmed by Simplicius (*On Aristotle Physics*, 140, 21). See: Lee, 1936, pg 22.

remain, a result which the argument regards as absurd without further explanation (139, 29-30).

3. The initial whole would be divided into a collection of “nothings”, which is also taken to be absurd (139, 31-2).

Since the above conclusions are unacceptable, the initial premise must be false. Therefore, the argument concludes that “being” is indivisible and without parts (139, 32; 140, 5-6). In the second argument (*On Aristotle Physics*, 139, 10-19; 141,1-8), Zeno intends to prove that if we presuppose that there are many things (P), each of the many would be both infinitely large (A), and so small as to have no size at all (B) (139, 8-9). The proof for (B) is missing from the passage, and Simplicius only provides a brief allusion: the plurality of existents have no size, because each of them is self-identical and one (139, 18-9).[387]

With respect to (A), the underlying reasoning is expounded in greater detail. At first (139, 10-5), Zeno demonstrates that something lacking “magnitude” (μέγεθος), or “size” (ὄγκος), or “thickness” (πάχος), cannot exist (probably understood in a material sense). For, let us assume that there is an “X” without magnitude. Since something lacking magnitude can neither increase nor decrease another magnitude, the addition (or detraction) of X will not change the other object’s magnitude (or size) in any way. From this Zeno concludes that X must be nothing, and non-existent. This conclusion will only follow in the case of corporeal things. In other words, if we understand “existence” in a material sense. Otherwise, considering incorporeal existences (like an idea of the mind or a dream image), even though their addition (or subtraction) does not necessarily change the magnitude of something corporeal, they still exist in some manner, in which case the conclusion that they are non-existent does not follow.[388]

The second part of the proof for (A) is described at (141, 1-6).[389] The language of this part is rather obscure, but the intended meaning seems to be as follows: utilising the

[387] For possible ways to supplement this part of the argument, see: Furley, 1967, pg 66-7; Vlastos, 1967, pg 369.

[388] For more on this part of the argument, see: Furley, 1967, pg 65; Vlastos, 1967, pg 370.

[389] There is an earlier allusion to this part of the argument at 139, 16-8, but the more detailed description comes at 141, 2-6.

conclusion of the first part, Zeno argues that in order for "what is" (τὸ ὄν) to exist (in a material sense), it must have magnitude.[390] Supposing the divisibility of "what is" (the primary premise), in order for them to "be", each of the many, into which it is divided, must also have magnitude, and must "lie separately" (ἀπέχω) from one another (141, 2-3). In other words, each of the many must be spatially distinguishable. Let us denote an arbitrary member of these as "Y". The above must hold true with respect to an arbitrary part (let this be "Z") of Y as well.[391] Therefore, Z also has magnitude, and is spatially separate from the other parts of Y. The same things can be said of the parts of Z, and so on. Since there is no such "last" part in this series, which is without magnitude or is not separate, the process can be repeated *ad infinitum*, yielding an infinite number of spatially extended and separate parts which constitute Y (141, 5-6).

There are two relevant corollaries of the above conclusion: firstly, the fact that Y was shown to consist of innumerable parts entails that it is infinitely divisible. In other words, based on the argument, the assumption that there are many separate things (the primary premise) leads to the infinite divisibility of matter. Secondly, without further steps, the argument concludes in an absurdity: Y (or each of the many things) is both infinitely large (A) and without magnitude (B) at the same time (141, 7-8). The proof for (B) was discussed on the previous page. In order to understand how this final conclusion leads to (A), the argument must be supplemented with the following: if Y has an infinite number of parts, each with a certain size or magnitude, the total sum of these parts must be infinite. Consequently Y (and each of the many) proves to be infinitely extended (the conclusion (A) mentioned above). As I have said, I will not refute this argument here. Nonetheless, let it suffice that the part of Zeno's reasoning which intends to prove (A) fails, because the final assumption (that the sum of the infinite number of parts must be infinite) mentioned above is wrong.[392]

After describing those arguments of Zeno which presuppose the infinite divisibility of matter, and conclude in various absurdities, let us turn to our main topic, and analyse

[390] Remember that, in these arguments, Zeno is questioning the divisibility of Eleatic being, the "what is" (τὸ ὄν).
[391] The argument refers to this as the part which "protrudes" (προέχω).
[392] For a possible refutation, see: Vlastos, 1967, pg 370-1.

the pertaining arguments of the Atomists. As we shall see, the early Atomists argued for the indivisibility of matter along somewhat different lines than the Epicureans. Accordingly, I will divide the material into arguments which are connected to the early Atomists (to Democritus and Leucippus), and into those which are used by Epicurus and Leucippus.

I will begin by considering the arguments of Democritus and Leucippus and whatever reply Aristotle furnishes to these arguments. Following a similar procedure as in the other chapters, prior to my actual analysis of them, I will ascertain the arguments which can safely be attributed to the Atomists, since these are the only ones relevant to my discussion. In the case of the early Atomists, their reasons for positing the existence of indivisible particles are preserved in second-hand sources. As a result, it is necessary to determine whether the argument in question could indeed have been used by the Atomists, and if so, to what extent it can be considered genuine. For instance, the argument found in *De Generatione et Corruptione* (316a15-17a1) is permeated by Aristotle's own ideas. Although its basic structure seems to be genuine, there are some parts of it which are evidently Aristotle's own addition.[393] In other words, it is only "partially" genuine. I will discuss the question to what extent this reasoning can be attributed to the Atomists further down.

There are two passages which attribute an argument for the existence of atoms to the early Atomists. Firstly, there is a brief reference to an argument in Simplicius:

"Those (the Atomists) who rejected unlimited cutting, because we cannot cut into the infinite, and, thus, gained evidence for the inexhaustibility of cutting, said that bodies consist of indivisibles and are divided into indivisibles."[394]

Here, infinite divisibility (or "cutting into the infinite") is rejected on the grounds that the action itself cannot be performed. In other words, one cannot take an object and actually divide it infinitely many times. The subsequent lines mention both the early Atomists and Epicurus by name which suggests that Simplicius attributes the reasoning to all of them. All in all, the argument itself is clearly fallacious, and even

[393] By having the same "basic structure", I mean that the early Atomists (probably) also had an argument which argued from the same (or similar set of premises), and via similar logical steps, resulted in a similar conclusion.
[394] *On Aristotle Physics*, 925, 10-12 (my own translation);

its authenticity is dubious.[395] Here, putting aside the question of its authenticity, I will only furnish a refutation of the argument. Even if we assume the premise that "the process of infinite division cannot be completed" to be true, the final conclusion that "bodies consist of indivisible atoms" will not follow by necessity. In a valid argument, if the premises are true, the relevant conclusions must hold true as well even if the argument is extended by additional premises. For instance, from the primary premise that "the universe, where all objects exist, is unique and finite in all directions", the conclusion that "all existing objects are finite in size" follows by necessity. After all, no matter what other premise is included in the argument, as long as the primary premise is true, the conclusion will be true as well. However, this cannot be said of the above argument related by Simplicius. Here, assuming its premise that "the process of infinite division cannot be completed" to be true, and further supposing that "an arbitrary object can be divided at any of its points",[396] will entail that the conclusion that there are atomic bodies cannot hold true. Otherwise, I could only divide the object at points where these atoms adjoin, and could not at those points which are situated within the indivisibles. Therefore, the final conclusion does not follow by necessity, and the argument fails to prove the existence of primary atomic bodies.[397]

In addition, there is the argument preserved in *De Generatione et Corruptione* (316a15-17a1). By and large, scholars accept that the basic structure of the reasoning indeed originates from Atomism.[398] However, as I have already mentioned, there is evidence that Aristotle modified some of the parts by including his own ideas. In my subsequent analysis, I will indicate the parts which are (probably) Aristotle's own addition, and did not feature in the original Atomists' version. Despite this, as far as I

[395] Barnes regards it as Simplicius' own invention on the grounds that, besides the passage in question, no other evidence connects such an argument to the Atomists (1982, pg 48-9).
[396] Since the two premises are not incompatible with each other, they can be assumed simultaneously.
[397] For an alternative way of refuting the argument, see: Barnes, 1982, pg 48-9.
[398] Both Cherniss (1964, pg 113) and Furley (1967, pg 85) argue that, although the argument seems to be permeated by Aristotle's own concepts, its underlying structure comes from Atomism. Other sources simply attribute the whole argument to Democritus without even mentioning the problem of its originality. (Joachim, 1922, pg 76; Sorabji, 1983, pg 338-41). For an analysis focusing on the parts which were either altered, or included by Aristotle, see: Furley, 1967, pg 83-5; Sinnige, 1968, pg 144-8.

see, there is sufficient evidence to conclude that Democritus also produced a similar argument for the existence of indivisible primary bodies.

Firstly, the fact that Aristotle himself attributed the argument to Democritus is fairly evident. Although this is not stated explicitly in the passage, I see no reason why else Aristotle would write the following right before the argument itself:

"For, whereas the Platonists argue that there must be atomic magnitudes 'because otherwise "The Triangle" will be more than one', Demokritos would appear to have been convinced by arguments appropriate to the subject, i.e. drawn from the science of nature. Our meaning will become clear as we proceed."[399]

The mention of the name and the phrase "δῆλον δ᾽ ἔσται ὅ λέγομεν προϊοῦσιν" (the meaning will be clear as we proceed) makes it fairly obvious that Aristotle has Democritus in mind when relating the argument. Secondly, as we shall see in the analysis, the argument adopts elements from both of Zeno's arguments mentioned above, a fact which entails that this kind of reasoning existed even before Democritus' time. Therefore, it could have been utilized by him when arguing against the infinite divisibility of matter. For instance, as Furley points out, part of the argument in *De Generatione et Corruptione* resembles that of Zeno (Simplicius, *On Aristotle Physics*, 139, 10-5).[400] For, according to Simplicius, to show that something with no magnitude cannot exist in a material sense, Zeno argued that: if "X" has no "magnitude" (μέγεθος), adding it to another magnitude will not increase its size. Consequently X must be "nothing" (οὐδέν). As we shall see, a similar line of thought underlies the argument related by Aristotle. Here, it is stated that if the division results in "nothing" (οὐδέν) or "non-magnitude" (ἀμεγέθη), the original whole (the thing being divided) cannot be reconstructed from such parts, and it would also end up as being "nothing but an appearance" (316a26-9). The proposition that "a non-magnitude cannot increase another magnitude" (Zeno's contention), and the statement that "the aggregate of 'non-magnitudes' cannot constitute a magnitude" are based on the same logic.

[399] *De Generatione et Corruptione*, 316a11-4.
[400] Furley, 1967, pg 84-5; For such a connection between Zeno and the early Atomists, see also: Taylor, 1999, pg 164.

Taking all of this into consideration, it is reasonably clear that Aristotle attributes this argument to Democritus, and there is also evidence that the underlying reasoning might well have been used by the Atomists. Accordingly, regarding it as genuine, I will include it in my analysis, where I will try to distinguish the original parts from the ones which were (probably) modified or added onto by Aristotle.

As I have laid down in the beginning, I am focusing on those passages which can be interpreted as discussing the physical (in)divisibility of bodies (or matter). Therefore, before commencing the actual analysis of the argument (*De Generatione et Corruptione*, 316a15-17a1), the question regarding the kind of divisibility being presupposed needs clarification. As I will demonstrate later on, several of Aristotle's arguments against indivisibles work well only if theoretical indivisibility is presupposed. In contrast, as I see it, this argument can be applied just as well to physical as to theoretical divisibility.[401] Firstly, the passage contains no words or expressions which might imply that the divisibility in question is theoretical. Secondly, as my analysis will demonstrate, the overall meaning of the argument does not change even when physical divisibility is presupposed. In addition, I will also point out certain indicators which show that the objects of this division are material substances (not distance or time). All in all, I will interpret the passage as an argument for the existence of physically indivisible bodies. However, as has been mentioned above, the original argument of the Atomists is heavily modified by Aristotle. Therefore, as an attempt to recreate the original version, I will try to disentangle the genuine "elements" from those which were probably added on by Aristotle himself. In addition, my analysis will concentrate only on those parts of the reasoning which might have featured in the original version as well. In contrast, if a part proves to be Aristotle's own addition (or modification), I will only indicate this fact, but not analyse it further.

[401] In this respect, my interpretation is in disagreement with that of Sinnige (1968, pg 145), who explicitly states that the argument in question works only with theoretical (or mathematical) indivisibility. However, he omits to adduce any examples to corroborate his statement. Contrary to Sinnige, Furley (1967, pg 93-4), who otherwise holds that Aristotle regarded the atoms of Democritus and Leucippus as theoretically indivisible as well, states that this particular argument concerns divisibility in a general sense. In other words, according to Furley, establishing a distinction between physical and theoretical divisibility is not required to interpret the argument.

Let us proceed to the actual analysis. At first, Aristotle describes the argument (for the existence of indivisible bodies), and then, he attempts to refute it. First of all, it must be noted that the argument (or at least, Aristotle's version of it) is not directed against the concept of infinite divisibility. Rather, Aristotle provides an argument which is aimed at showing the impossibility of a "magnitude" (μέγεθος) which is "divisible everywhere" (πάντῃ διαιρετός).[402] As Sorabji points out, being divisible everywhere is not entirely identical with infinite divisibility.[403] For instance, if we divide a straight rod via bisections even if it could be carried out infinitely many times, the points one third away from either end point will never be subject to division. In contrast, divisibility everywhere includes these points as well, since it means to be divisible "at any and every point". Consequently, the latter is the broader term, since it entails infinite divisibility, but the converse is not true.

Nonetheless, the expression πάντῃ διαιρετός does appear in other passages which relate Eleatic arguments against infinite divisibility.[404] Although the term itself is often associated with infinite divisibility, aside from the one found in *De Generatione et Corruptione* (316a15-17a1), there is no extant passage which connects the usage of πάντῃ διαιρετός directly to Democritus.[405] Nonetheless, I will retain Aristotle's expression, and analyse the argument as being directed against the possibility of dividing a material object everywhere (and not against infinite divisibility unqualified). I have two reasons for doing so. Firstly, certain logical steps within the reasoning make more sense, if divisibility everywhere (and not infinite divisibility unqualified) is presupposed. Secondly, as we shall see, Aristotle replies by showing

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402 Throughout the argument, Aristotle consistently uses the expression πάντῃ διαιρετός, which can be understood as the ability of a body to be divisible "at any point whatsoever" (καθ᾽ ὁτιοῦν σημεῖον) (316b19-20).

403 Sorabji, 1983, pg 338.

404 *De Generatione et Corruptione*, 325a8; The expression also appears in Zeno's argument discussed on pg 141-3. Here, Simplicius even provides a reason why, in the case of homogenous bodies, the property of divisibility should entail divisibility everywhere (*On Aristotle Physics*, 140, 1-2). Since the object of division is "homogenous" (ὅμοιος), it is similar in nature at any of its points. Consequently, it should be divisible at every one of these points. In other words, it should be divisible everywhere.

405 For instance, Simplicius, when recounting the argument of the Atomists against infinite divisibility (*On Aristotle Physics*, 925, 10-12), uses expressions like "cutting into infinity" or "to cut something into infinity" which feature the different derivations of the verb "to cut" (τέμνω). With respect to latter Atomism, the relevant arguments of Epicurus also contain these expressions (Diog. L., x.41 and 56). Therefore, the phrase "divisible everywhere" is not present in Atomism.

that, in a sense, divisibility everywhere is possible. Hence, in order to properly appreciate his solution, the concept of divisibility everywhere is still required.

The argument itself is a *reductio ad absurdum* aimed at demonstrating the absurd consequences which would result if bodies were divisible everywhere. It goes as follows: in the first part (316a17-23), it is assumed that if a "magnitude" (μέγεθος) is divisible everywhere, this division must be possible. From this, it follows that we can arrive at a state when the object has already been divided everywhere.[406] This does not mean that either Aristotle or Democritus takes it for granted that there are objects out there which have already undergone such a division. Rather, this part of the reasoning is more akin to a thought experiment which assumes a supposedly existing possibility (the divisibility at every point), and simply considers what would happen, if such division were to occur.[407] As Aristotle repeats several times, nothing "impossible" (ἀδύνᾰτον) would result, if an object were to be divided at every point, albeit, perhaps, nobody could actually take an object and carry out such a division on it (316a22-3). It is the possibility (of "division everywhere") itself, which entails that even if it were to occur and the object were (or would have been) divided at all of its points, nothing impossible would result. The main point here is the assumption that "if a possibility really exists, its outcome must be realizable as well".

Therefore, the notion that "all possibilities must be realizable" seems to underlie this logical step. Although this is certainly an Aristotelian notion,[408] there is no reason to deny that this step also featured in the original argument of the early Atomists, although there is no extant passage which explicitly attributes the above notion to the Atomists, and, unlike Aristotle, they probably did not formulate this principle as a general rule. Nonetheless, since this step is essential to the logical structure of the argument (without it the next step could not follow), I will regard it as being part of Democritus' reasoning as well. In the next step, assuming that the division

[406] At 316a18 Aristotle points out that it is not required that the infinitely many instances of division occur "at the same time" (ἅμα). It could even be the end result of a process of division lasting for an indefinite amount of time.

[407] As Aristotle's phrasing shows at 316a19, the actual occurrence of a state, where the object has been divided everywhere, is envisaged as more of a "remote" possibility: "if this (division) **were to** happen, nothing impossible **would** result" (εἰ τοῦτο γένοιτο, οὐδὲν ἂν εἴη ἀδύνατον). The optatives in the conditional clause, express a "remote" condition in the future which might never be realized.

[408] For more on this question, see: chapter II, pg 24-5.

everywhere has already happened (316a23-4), several absurd consequences of it are being discussed in turn:

1. The possibility that the divided parts have μέγεθος (here, understood as spatial extension) is rejected right away on the following grounds: since these magnitudes (of the parts) could be further divided, the process of division is incomplete, and the object cannot be in a state when it is divided everywhere (316a24-5). Later on (16a34-b2), Aristotle reconsiders this possibility by stating that small pieces of matter, such as "sawdust" (ἐκπρίσμα), might survive the division. Since even such small pieces have magnitude and can be further divided, the same conclusions still apply (16b2). Therefore, the argument goes on to consider possibilities where the divided parts do not have a magnitude.
2. If the surviving parts cannot have magnitude, the divided object must be composed of "non-magnitudes" (ἀμέγεθη). Here, three alternatives are being distinguished (316a25-8, b2-3): 2/a, the object in question is made out of "points" (στιγμαί); 2/b, its parts are "nothing" (οὐδέν); 2/c, either the "form" (εἶδος), or a "quality" (πάθος) of the object remains after the division.

The conclusion (2/c) is probably Aristotle's own addition, and did not feature in the original argument. After all, applying the term "separable" (χωριστός) in this way to the form or a quality of a perceptible body is reminiscent of the *Metaphysics'* usage of it in connexion with "substance" (οὐσία).[409] In this context, "separability" means the ability to exist independently (not as a part or attribute of something else) in a material sense. That's why, in (2/c), Aristotle refers to form and quality as separable, since these are the only ones which are assumed to exist by the argument, after the material object has been divided everywhere. Returning to the question of genuineness, since there is no evidence which might suggest that the early Atomists used χωριστός in this sense, and applied it to the form (or shape) of objects, (2/c) is most likely Aristotle's own addition. With respect to the remaining conclusions of (2/a) and (2/b), as Furley points out, it is likely that the distinction between "points"

[409] In the *Metaphysics*, only substances are said to be separable (1029a28), whereas the other categories, such as quality or quantity, are not. For our present purpose it is enough to define the corresponding meaning of χωριστός.

and "nothings" is Aristotle's own, and did not appear in the original version.[410] There is an additional passage (316a10-4), which discusses the implications of divisibility everywhere being carried out. However, note the presence of characteristically Aristotelian terms, such as "potentially" (δυνάμει) at b12, and the idea of "the body being dissolved into qualities" (just as in (2/c)). These features suggest that this passage is also Aristotle's own addition.

Then, what conclusion could the Atomists possibly draw? In my opinion, if Democritus indeed adopted Zeno's reasoning that "something without a magnitude must be 'nothing' (οὐδέν)",[411] he could maintain (2/b), and say: if the process of dividing everywhere cannot leave behind parts possessing magnitude, it must divide the object into "nothings". In fact, the same reasoning is also present in Zeno's argument (see: conclusion (3) on page 142), which provides further evidence that this reasoning existed before Democritus' time, and could have been utilised by him as a possible absurd conclusion resulting from the infinite divisibility of spatial magnitudes.

To sum up, so far, the original argument probably looked like the following: if divisibility everywhere is possible,[412] this possibility must be realizable. Therefore, let us suppose that it happens, and the object has already been divided in such a manner. However, in this state, the object must consist of nothings and non-magnitudes, or else the division can still continue (since the object is still not divided everywhere). Then, the argument proceeds to consider the absurd implications of (2/b): the object "could be created" (γίνοιτο) out of nothings (316a28, b26-7); it would be a "composite" (συγκείμενον) of nothings (16a28); it would entail that the material body is "nothing but an appearance" (16a29). Among these, the first conclusion seems to be the most likely one which the Atomists could have used, since it explicitly contradicts the Eleatic principle that "nothing can be created from nothing" which

[410] Furley, 1967, pg 85.
[411] I already argued for this possibility on page 146.
[412] As I have said, Democritus probably did not use the expression "divisible everywhere" (πάντῃ διαιρετός). However, I have already stated the reasons why this expression should be preserved when analysing the argument (see: pg 148-9).

was adopted by the Atomists as well.[413] Having enumerated the absurdities which follow if the object is divided at every point, Aristotle concludes the argument:

"Hence (it is urged) the process of dividing a body part by part is not a 'breaking up' (θρύψις) which could continue ad infinitum; nor can a body be simultaneously divided at every point, for that is not possible; but there is a limit, beyond which the breaking up cannot proceed. The necessary consequence especially if coming-to-be and passing-away are to take place by association and dissociation respectively is that a body must contain atomic magnitudes which are invisible."[414]

In order to render "generation" (γένεσις) and "destruction" (φθορά) possible, both divisibility everywhere and the process of "breaking up" (θρύψις) *ad infinitum* should be rejected.[415] Therefore, the process of breaking up must terminate at a "given point" (μέχρι), at the level of "atomic magnitudes" (ἄτομα μέγεθη) which cannot be further divided. The expression "atomic magnitudes" could well be a reference to the primary bodies of the Atomists. The fact that they are called "invisible" (ἀόρατος) corroborates this notion.[416] In addition, the statement that "generation and destruction occur by means of 'association' (σύγκρῐσις) and 'dissociation' (διάκρῐσις) respectively" could also be regarded as a reference to Atomism.[417] Consequently, if the Atomists indeed produced a similar argument, its conclusion probably bore a close similarity to the one reported by Aristotle.

There are two additional features which are unique to the above passage (316b29-17a1). Firstly, this is the only place within the argument, where infinite divisibility (or dividing *ad infinitum*) is mentioned alongside divisibility everywhere. Secondly, the term θρύψις, which means "breaking into smaller pieces", describes a physical action, and might suggest that the division envisaged is in fact physical in nature. This idea is supported by the previous lines where the process of division is described as leading to ever smaller magnitudes which are actually "separated" (κεχωρισμένα) and "kept away" (ἀπέχοντα) from each other (16b27-8). However, I would not go as far as to

[413] Diog. L., x.44; Furley, 1987, pg 117.
[414] 316b29-17a1.
[415] The impossibility of generation has already been mentioned (316a28, b26-7). The fact that this also entails the impossibility of destruction is presupposed by the argument.
[416] The primary bodies of the Atomists were undetectable to the human eye owing to their smallness (*De Generatione et Corruptione*, 325a30; Simplicius, *On the Heavens*, 295, 5-6).
[417] According to Atomism, the generation and destruction of composite bodies are effected by the association and separation of the constituent atoms (*De Generatione et Corruptione*, 315b6-9; Simplicius, *On the Heavens*, 295, 22-4).

assert that this is an argument solely against physical division *ad infinitum*. Rather, as I see it, there is nothing in the above reasoning which suggests that the division is theoretical only, and the logical structure is not affected by the type of division being presupposed. What is more, as we have seen, there are parts which accord better with physical division. Consequently, since my discussion focuses on the physical division (of bodies), I regard this argument as being directed against the possibility of physically dividing an object into the infinite.[418]

After reconstructing what the Atomists' reasoning could have been originally, let us consider the question whether their argument is successful in proving that there is a lower limit to the physical division of matter or not. The following will show that the argument is fallacious, and cannot prove the existence of indivisible atoms. Let us see why. In his reply to the argument (317a2-12), Aristotle distinguishes two different senses in which a magnitude can be πάντῃ διαιρετός (317a3-4). In its "unqualified" sense (let this be called type "A"), divisibility everywhere simply means that the object can be divided "anywhere" (ὁπῃοῦν), at every conceivable point (a7-8). This is the kind of divisibility which Aristotle accepts, since it does not render the divided object into a collection of "nothings".[419] After all, the fact that I can cut the object anywhere I wish does not seem to entail that the body can be reduced to "nothings". In contrast, Aristotle argues that if the division were to occur "simultaneously" (ἅμα), which I will refer to as type "B", it would mean that the object is separated at all of its points at the same time, and would end up as a collection of nothings or points (17a5-7). Divisibility everywhere in this latter sense is rejected even by Aristotle (316b22-3). He argues that divisibility everywhere in this sense requires that the points of division are "in succession" (ἐφεξῆς) and "consecutive" (ἐχόμενος).[420] However, as Aristotle rightly observes, points cannot stand in such a relation to each

[418] The fact that the divisibility concerns physical bodies (not geometrical objects, abstract space or time) is fairly obvious. Firstly, alongside "magnitude" (μέγεθος), the word "body" (σῶμα) is also referred to as the object of division (316a15, 23, 16b1). Secondly, the process of generation and destruction, mentioned in the final passage (316b33), can only concern material objects.

[419] The proposition that "the object of infinite division ends up as a collection of 'nothings'" is the conclusion which the original argument of the Atomists (probably) contained (see: 2/b on pg 150).

[420] 317a9-12; For the meaning of ἐφεξῆς and ἐχόμενος, see: *Physics*, 226b34-27a6. In brief, two things are said to be "in succession", when nothing of the same kind comes in-between. For instance, two boats moored next to each other are in succession, because there is only water between them. Two things are "consecutive", if they are in succession, and their boundaries occupy the same place.

other. After all, considering a line, no matter how close we take two points on it, there remains an infinity of other points which separate them.

Notwithstanding Aristotle's correctness in saying that points are not consecutive, as Sorabji points out, the possibility of something being divided everywhere simultaneously does not necessarily require the consecutiveness of points.[421] After all, one can both accept the latter and still maintain that divisibility occurs at every one of such non-consecutive points. Therefore, one cannot argue from the non-consecutiveness of points to the impossibility of dividing an object everywhere simultaneously. However it is not even required to consider this possibility. After all, from the primary premise of the argument that "objects are πάντῃ διαιρετός" it does not necessarily follow that "any object would end up in a state when it has already been divided everywhere". Consequently, the further conclusion "that bodies would end up as collections of nothings" (2/b) will not hold either. For in its unqualified sense (type A), divisibility everywhere only means that the object can be separated at any of its points, the possibility of which is not identical with the possibility of dividing something everywhere simultaneously (type B).

In order to facilitate understanding, let us reiterate the first part of the original argument which is as follows: "if divisibility everywhere is possible, this possibility must be realizable. Therefore, let us suppose that it happens, and the object has already been divided in such a manner." Since divisibility everywhere has two different senses, the "actualization" of their respective possibilities must be different as well. Therefore, supposing type A divisibility, its actualization (that I actually divide the object at any of its points) will not lead to the state when the object has already been separated at all of its points, since this latter occurrence is the actualization of type B divisibility (not type A). Since, in the beginning, the argument does not qualify πάντῃ διαιρετός (whether it should be regarded as type A, or B, or something else), the conclusion that "the body has already been divided everywhere" does not follow by necessity. Since (2/b) depends on this conclusion, it will not hold either, and the

[421] Sorabji, 1983, pg 339.

whole argument loses its force. Consequently, assuming type A divisibility, the argument does not work.

In fact, for those, like Aristotle, who argue for the infinite divisibility of matter, the existence of type A divisibility is sufficient. After all, if I can cut bodies anywhere I wish (assuming that I have the required physical capabilities), the objects cannot consist of indivisible magnitudes. Otherwise, I could only divide the object at points where these magnitudes adjoin, and could not at those points which are situated within the indivisibles. That's why, in his counter-argument, Aristotle accepts the type A divisibility, but dismisses type B which might lead to the absurdities mentioned by his opponents.

So far, we have examined two arguments of the early Atomists (*De Generatione et Corruptione,* 316a15-17a1; Simplicius, *On Aristotle Physics*, 925, 10-12), and concluded that neither of these arguments manages to provide conclusive proof for the existence of primary indivisible bodies. Let us turn to Epicurus and Leucippus, and see whether they fare better in this respect or not. Before, looking at their arguments, it must be mentioned that, concerning the divisibility of atoms, Epicurus' account differs from that of Democritus and Leucippus.

As we have seen at the beginning of this chapter, whether the early Atomists regarded their atoms as theoretically divisible or indivisible is controversial, and only physical divisibility can be safely attributed to their primary bodies. In contrast, based on the textual evidence, it is fairly certain that Epicurus (and Lucretius) upheld the view that, although the atoms are physically indivisible, they are composed of parts, referred to as the "minimal parts of atoms", which are only distinguishable by the mind (within the atom, they cannot be separated from each other physically).[422] In other words, the Epicurean atoms, despite being physically uncuttable, are theoretically divisible. Consequently, whereas, in the case of Democritus, it might be possible to talk about the indivisibility of his atoms in a general sense (without making

[422] The passages discussing the "minimal parts of atoms" are: Diog. L., x.58-9; Lucretius, *De Rerum Natura*, 1.599-634, 746-52. For relevant secondary literature, see: Bailey, 1928, pg 286-7; Furley, 1967, 7-43; Sorabji, 1983, pg 371-5. There is also a useful discussion on Epicurus' account by Gregory Vlastos: 'Minimal Parts in Epicurean Atomism', *Isis*, vol.56, No.2, pg 121-47 (1965).

a distinction between physical and theoretical divisibility), in the case of Epicurus and Lucretius, it must be borne in mind that their primary bodies are only physically indivisible. As a result, when discussing their arguments against infinite divisibility, the kind of divisibility being considered by a particular argument must be ascertained, since theoretical divisibility goes beyond the level of atoms, which themselves are physically unsplittable. Seeing that my focus is on the physical divisibility of matter, I will consider the arguments which attempt to prove that the physical cutting up of matter cannot go on *ad infinitum*. In the case of Epicurus, his relevant arguments are preserved by Diogenes Laertius (x. 41 and 56-7). By and large, Lucretius adopts Epicurus' reasoning, but develops it further (*De Rerum Natura*, 1.538-64).

In x.56-7, Epicurus furnishes two separate arguments against the infinite division of bodies, of which the first one is mentioned earlier (x.41) as well. Although Furley regards both arguments as concerning the theoretical division of atoms, I think it is fairly evident that they relate to the physical division of regular objects (not atoms).[423] In my upcoming analysis, I will demonstrate this fact. For the time being, I will adduce only the following reason. The lines introducing both arguments (x.56) make it fairly certain that the question at issue is the physical division of everyday objects. The fact that compound objects (and not atoms) are concerned is revealed by the following. The statement that "no 'finite body' (ὡρισμένον σῶμα) can consist of an unlimited number of parts" is connected by ὥστε to the actual description of the arguments in question. In Atomism, the words ὡρισμένον σῶμα usually refer to regular, compound bodies (not atoms), and the word ὥστε suggests that the subsequent arguments concern these regular objects. In addition, it seems likely that the word ὡρισμένα (finite things) a few lines down, is a reference to the above ὡρισμένον σῶμα, a fact which further corroborates the notion that the argument concerns the division of everyday objects (not atoms). Let us put this question aside for a bit, and proceed with the analysis.

[423] In Atomism, regular objects are distinguished from their constituent atoms in several respects. Here, the important difference is that everyday objects can be dissolved into parts until we reach the level of atoms, which can no longer be divided. For Furley's pertaining discussion, see: 1967, pg 13-4.

The fact that, in x.56, we are dealing with two separate arguments is clearly brought out by the way Epicurus phrases the passage: the two arguments are separated by the close “not only.., but also…” (οὐ μόνον…, ἀλλα καί…), where the first one comes in-between, and the second follows ἀλλα καί. From here onwards, I will examine them in turn. The first reasoning appears in x.41 as well. Lucretius’ version of it (*De Rerum Natura*, 1.538-64) is more detailed, and I will refer to it whenever it is relevant. Although Furley thinks otherwise (see: above), most scholars agree that the argument concerns the physical division of regular bodies (not atoms).[424] The physical nature of the division is suggested by the expression ἄπειρον τομὴν, applied to it in x.56. The word τομὴν is related to τέμνω (to cut) which usually indicates physical separation into two parts.

The argument rejects the possibility of “unlimited cutting” on the grounds that it would render bodies too “weak” (ἀσθενής), and destroy them into “non-existence”. In x.41, as an explanation, Epicurus adduces the “dissolution of compounds” (διάλυσις τῶν συγκρίσεων), a phenomenon which is well-attested by the senses.[425] Although not explicitly formulated, Epicurus probably thinks that if matter can be dissolved (or divided) ad infinitum, over time, such a process would render everything “non-existent”. Lucretius further elaborates this point. Although he mentions the above conclusion at 1.540, the underlying reason is expounded later (551-61). In order to facilitate understanding, I will slightly alter the original structure of the passage. Lucretius’ basic assumption is that an arbitrary object’s disintegration is faster than its “reconstruction” (1.556-7).[426] Therefore, if matter was indeed infinitely divisible, by the bygone ages (regarded as infinite), the faster rate of dissolution would have already ground everything to such small pieces that they would virtually

[424] For instance, see: Bailey, 1928, pg 204-5; Sorabji, 1983, pg 348.
[425] Since the dissolution (or destruction) of compounds is evidenced by the senses, according to Epicurus, it must be accounted for. After all, in Epicureanism, the information from our senses is regarded as valid, and every proper physical theory must be in accordance with it. In addition, the fact that, in both Epicurus’ and Lucretius’ description, the process of infinite divisibility is illustrated by the dissolution of compounds is yet further evidence that these arguments concern the physical divisibility of regular objects.
[426] This is a reference to the generation and destruction of material objects, which is accepted by the Epicureans (and even by Aristotle) as an empirical fact.

amount to nothing.[427] If all things had been reduced to nothing by the process of dissolution, and in accordance with the principle that "nothing can originate from something non-existent" (1.543-44),[428] nothing can exist now. This is an absurd conclusion, since we see many things around us (542). In order to avoid such an absurdity, the infinite divisibility of matter must be dismissed. Hence, underlying the material objects, there must be something indivisible (the atoms) which, by virtue of being "strong" (ἰσχῡρός) and "solid" (πλήρης), can survive the dissolution of compounds, and provide a firm basis for their recreation (1.545-50; Diog. L., x.41).[429]

Although sharing certain similarities, this is a different argument than the one used by the early Atomists (*De Generatione et Corruptione*, 316a15-17a1). For instance, both presuppose infinite divisibility, but the latter specify it as "divisibility everywhere". Both arguments result in the absurdity of spatially extended bodies ending up as "nothings", but they reach this conclusion in different ways. In the case of the early Atomists, it is the process of dividing the object at all its points which is supposed to yield such a result. In contrast, the Epicureans argue that if there is no limit to the division, the dissolution of bodies, which has been occurring for an infinite time, would have already ground the particles to such an extent that they would be like "nothings", a state from which recreation is not possible.

We have already seen that the argument of the early Atomists is unconvincing. Can the "modified" version of the Epicureans conclusively refute the infinite divisibility of matter? If we accept Lucretius' premises that the process of breaking up is faster than the reconstruction, and the available time is infinite, the size of the resultant particles (of matter) would indeed converge to "0". However, Epicurus' solution does not work either, since the assignment of a lower limit to the division only changes the limit: in this case, the size of the particles would converge to that assigned limit, which are

[427] The fact that these (infinitely) small pieces, resulting from the endless dissolution, are regarded as nothings by Lucretius is suggested by lines 540-1, where the very same process turns things into "nothing" (*nihil*).

[428] See also: Diog. L., x.38.

[429] In Lucretius' version of the argument, the atoms can survive the process of dissolution, by virtue of both being "solid" (*solidus*), and lacking void. The argument also explains the role of void in the dissolution of objects (1.532-5). By and large, bodies disassociate by means of their internal void interstices. Since an atom lacks void altogether, it cannot be dissolved. The early Atomists assigned a similar role to void in the process of dissolution (Aristotle, *De Generatione et Corruptione*, 325b3-5).

the atoms. In other words, by now everything would have been disintegrated to its constituent atoms, which is no less absurd than the original conclusion (that the particles would become "nothings").

However, it is possible to avoid such a difficulty, if we assume that, with respect to each particular object, the processes of dissolution and (re)generation are not simultaneous, but consecutive.[430] This way, no matter how many times faster the process of dissolution is assumed to be, by virtue of a subsequent regeneration, something might still be recreated. Therefore, the absurd conclusion that "the object, undergoing these processes, is grinded into nothingness" (see: above) could be avoided. After all, since these processes are not simultaneous, the dissolution cannot counteract the slower reconstruction, which always occurs afterwards.

In fact, the assumption that the processes of dissolution and (re)generation are consecutive is compatible with both Epicurus' and Leucippus' wording, and accords well with experience. After all, with respect to natural things, we witness that, by and large, growth and decay do not happen simultaneously, but follow one another in turn. Both Epicurus and Lucretius must have something similar in mind, when stating that we need strong and insoluble particles, which can "survive" (ὑπομένω) the dissolution of compounds, and provide a firm basis for the subsequent recreation (Diog. L., x.41; *De Rerum Natura*, 1.545-50). In fact, even if the processes of dissolution and regeneration are assumed to be consecutive, the concern still remains that dissolution "breaks up" matter to such an extend from which subsequent reconstruction is not possible. Therefore, according to the Epicureans, physical matter must be composed of indissoluble particles (the atoms) which remain unaffected by the dissolution of compound bodies.

All in all, the veracity of this reasoning depends on how we look at the dissolution of compounds in general. If we regard all forms of disintegration as inevitably grinding matter into infinitely small pieces, the Epicurean argument seems to work. However, this is not necessarily the case, and Aristotle would have probably rejected such a notion as well, since his own views on generation and destruction are essentially

[430] Whether we take the generation of the object first then its dissolution, or proceed from its dissolution to the recreation of something new, our assumption holds in either case.

different. Generally speaking, the Atomists explain the above processes by the association and dissociation of the constituent atoms.[431] In contrast, Aristotle explicitly denies that "generation" (γένεσις) and "destruction" (φθορά) occur through association and dissociation respectively (*De Generatione et Corruptione*, 317a20-2). Rather, Aristotle explains all forms of change (including generation and destruction) as the "underlying matter" (ὑποκείμενη ὕλη) acquiring (or discarding) different forms, a process which does not necessarily involve dissolution or association.[432] As a consequence, Aristotle would most probably reject the idea of the Epicurean argument that the possibility of infinite divisibility entails: during their destruction, the objects would disintegrate into infinitely small pieces (let us denote this deduction as "X"). In fact, he seems correct in rejecting such a notion. After all, taking any organism (for instance, a particular tree), its creation, growth, and subsequent decay is a complex biological process which cannot be simply labelled as the association, and subsequent dissociation of its constituent particles. If we look at the structure of the Epicurean argument (see: above), we can see that X forms an important link in it. Without X, the absurd consequence of "everything being reduced to nothing" does not hold. Therefore, having dismissed X, the whole argument is rendered inconclusive.

Let us see whether the second argument of Epicurus proves to be more effective or not. As I have mentioned, it starts right after ἀλλα καί in x.56. I have already indicated that the argument concerns regular bodies (see: page 156). With respect to the nature of the division, as we shall see, it is entirely possible to interpret the argument as dealing with physical divisibility. Accordingly, I will interpret the first two lines (end of x.56), as assuming the possibility of infinitely divisible, finite bodies,

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[431] Aristotle, *De Generatione et Corruptione*, 325a31-2.

[432] Strictly speaking, in Aristotle's theory, there are three things involved in change: the matter, the "form" (εἶδος), and the privation of the form. For instance, in the case of a bronze statue, at first, there is the bronze (the matter) without the form of the statue. The change (its production) is completed, when the bronze actually acquires the form of the statue. Depending on the nature of the change, various things can assume the role of "matter" (even individual substances, like Socrates). The important thing is that the underlying matter is never in an "undefined" state, but always assumes some form, be it before or after the change. This is just a brief glimpse into Aristotle's theory of change. For more information concerning Aristotle's general theory of change, see: Ross, 1923, pg 62-66 and 99-108; Waterlow, S, *Nature, Change, and Agency in Aristotle's Physics* (Oxford, 1982). For the difference between generation and other forms of change, see: *De Generatione et Corruptione*, 317a25-7, 319b6-24 (including Joachim's commentary).

where the division is understood as physical. Just like in the previous argument, here, Epicurus makes the above assumption. Then, in x.57, he describes two supposedly absurd consequences which follow, if the assumption is valid.

In the first part of x.57, Epicurus presumes that any finite body could contain infinitely many "particles" (ὄγκοι).[433] Since these particles must be "of some size" (πηλίκος), no matter how small they are, their total volume would add up to infinity. It follows that the original body, which was assumed to be limited in size, would prove to be unlimited. Consequently, the assumption is false, and neither can any finite object contain infinite parts nor can it be infinitely divisible. The second part opens with the statement that "every finite thing has an 'extremity' (ἄκρον)".[434] In order to make sense of what follows, it is reasonable to assume that the word "finite thing" (τὸ πεπερασμένον) denotes one from the (infinitely numerous) parts of a body, discussed in the preceding part. Therefore, the extremity should be understood as belonging to such a part. Although not visible in itself, in thought, it is "distinguishable" (διαληπτός) from its surroundings, and this also holds true for the ἄκρον of the subsequent part. Due to the unlimited number of such parts (the primary assumption), by proceeding, and mentally distinguishing each extremity in turn, it would be possible to reach the infinite "in thought" (τῇ ἐννοίᾳ), a conclusion whose absurdity is regarded as self-evident by the argument. Consequently, in order to avoid it, one must reject the idea that a finite object contains an unlimited number of particles, and is infinitely divisible.

As I see it, neither of the above arguments (referred to as first and second part) require us to specify the nature of the division at issue. Although Furley and Sorabji regard both as concerning theoretical division, in my view, it is perfectly possible to furnish an interpretation without specifying the type of the division in question.[435]

[433] This assumption is implicitly derived from the primary supposition (end of x.56) that any finite body can be divided *ad infinitum*. Such a process is supposed to result in a state where the body is separated into infinitely many parts.

[434] According to Epicurus, the possession of a "limit" (ἄκρον), outside which no parts of the object are situated, is an inherent property of all finite extensions (Diog. L., x.41).

[435] In their analysis of the argument, neither Bailey (1926, pg 207), nor Hicks (1962, pg 244-5) refers to the nature of the division, which also bears testimony to the fact that it is possible to interpret the reasoning without specifying the kind of division at question. In contrast, as I have already mentioned (see: pg 156), Furley regards all of Epicurus' pertaining arguments as concerning theoretical division.

After all, in the first argument of x.57, the underlying reasoning that the "parts of a finite body, if unlimited in number, would have an infinite volume" is not altered by the question whether the parts themselves are physically divisible, or just theoretically. It might be argued: 1, the progression from one extremity (or part) to another, mentioned in the second half of x.57, is explicitly stated as a mental process; 2, albeit not necessary, it makes the arguments more intelligible, if we leave the finite body in question physically "intact", by only mentally distinguishing its parts (not separating them in actuality). However, neither (1,), nor (2,) entails that the parts themselves are only theoretically divisible (not physically). After all, the kind of (infinite) divisibility, being questioned, depends on the nature of the parts (into which the object is separated). Therefore, in the above instance of mental division (1,), there are two alternatives: a, we can mentally divide something into parts which are further divisible physically; b, the same mental division yields parts which can no longer be separated physically, but which are still divisible theoretically (in the mind). From these, only (b,) entails that the argument exclusively concerns theoretical divisibility. However, since the reasoning works with both (a,) and (b,), and there is nothing in it which might restrict it to either, it is perfectly legitimate to interpret the passage as concerning physical divisibility. In fact, the essence of the arguments lies in the notion that infinite divisibility (be it theoretical or physical) results in an infinite number of spatial extensions (all having some size), which lead to the above absurdities.

Returning to the efficacy of these arguments, can either of the two recounted in x.57 dispense with the idea of infinite divisibility? In essence, the first one is based on the notion that taking an infinite number of spatial entities, the total sum of their volume cannot be finite. This notion has already recurred in a similar argument against the limitedness of the universe (Diog. L., x.42).[436] There, Epicurus rejected the idea that

Sorabji only considers these last two theoretical (or in his words, "conceptual") in this respect, but the ones in Diogenes Laertius (x.41 and 56) he regards as physical (1983, pg 348-9).

[436] The idea that "an unlimited number of spatial entities, each with a certain size, must add up to an infinite volume" was already present in one of Zeno's arguments (see: pg 141-3). Since, as we have seen, there is evidence that the early Atomists adopted certain elements from Zeno (albeit, this particular idea features in neither of their above considered arguments), Epicurus also could have taken the idea in question from Zeno.

our universe is finite in extent on the grounds that, in that case, there would not be enough room for the unlimited number of atoms. However, as I have already indicated in my refutation of the argument, this reasoning only works, if we assign a lower size limit to the members (in the present case, the parts of the finite body) of the infinite series.[437] However, there is nothing in x.57, which might prove the existence of such a size limit, and Epicurus' opponents would have undoubtedly objected to it, since infinite divisibility entails that no matter how we choose such a limit to size, we can always reach smaller particles through division. In other words, in infinite divisibility, the volume of the parts converges to "0". Therefore, in order to make it work, Epicurus' argument needs to be supplemented with a proof for the existence of such a limit with respect to size. One might argue that this was already done in x.56, where it was argued that, in order to avoid the destruction of the object (via the process of dissolution), its division could not proceed into ever-smaller parts. However, I have already refuted this reasoning on different grounds (see: pages 158-60). All in all, looking at it in separation, the argument furnished in the first half of x.57 is deficient, and cannot refute the infinite divisibility of matter.

With respect to the second argument recounted in x.57, the only conceivable way, in which its supposedly absurd conclusion of "arriving into the infinite in thought" could be a logical consequence of infinite divisibility, is to assume that Epicurus rejects even the possibility of reaching the infinite in such a manner. Otherwise, it would be illogical to assume the actual occurrence of such an event based solely on the possibility of infinite divisibility. For instance, from the supposition that the "universe is destructible", it does not follow that it will inevitably be destroyed in the future. Instead, the supposition entails only the contingency of destruction. Therefore, if we want to refute the supposition, we need to deny even the possibility of the destruction of the universe. Similarly, Epicurus must reject even the possibility of "arriving into the infinite in thought", or else his conclusion will not be a consequence of infinite divisibility. Hence, despite the fact that it is not explicitly expressed in the passage, I will regard the argument as concluding in the above possibility, and

[437] For the entire explanation, see: chapter II, pg 30-31.

through its rejection, dismissing the primary premise (that finite objects can be divided *ad infinitum*).[438]

Taking the above into consideration, does the possibility of infinite divisibility indeed lead to the **possibility** of reaching the infinite in thought? I think it does not. First of all, the process of division will never yield an actual infinite set of ὄγκοι. Rather, the number of parts only converges to the infinite. Therefore, by counting their extremities in the mind (as told by the argument), one just keeps getting closer to the infinite, but in effect never reaches it. Therefore, the supposedly absurd conclusion of "arriving into the infinite in thought" will never occur. Secondly, even without infinite divisibility, there are other features in the Epicurean system (the atoms in particular), whose infinite multitude also involves the possibility of "reaching the infinite in thought". After all, similarly as with the extremities of the parts (of a finite object), one can "distinguish" (and add up) the extremities of all the atoms, and arrive into the infinite in this manner. Therefore, the conclusion of "arriving into the infinite in thought", which Epicurus rejects, can, in a sense, be regarded as a concomitant of his own system; a fact which raises the question whether Epicurus has the right of using this conclusion as part of a *reductio ad absurdum* in the first place.[439] Based on these considerations, the second argument of x.57 also fails to provide a definite proof for the existence of primary indivisible particles.

In summary of the present section of my work, my analysis has revealed that neither the arguments of the early Atomists (*De Generatione et Corruptione,* 316a15-17a1; Simplicius, *On Aristotle Physics*, 925, 10-12), nor that of Epicurus (Diog. L., x. 41 and 56-7) and Lucretius (*De Rerum Natura*, 1.538-64) manage to prove that matter is not infinitely divisible, but consists of primary particles (the atoms), which cannot be further separated physically.

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[438] The question would be less complicated in Aristotle's case, who upholds the notion that "all possibilities must be realizable". Therefore, for him, the possibility of "arriving into the infinite in thought" indeed entails that this action must be feasible as well. However, with respect to Epicurus, there is no evidence which suggests that he also upheld Aristotle's notion as a general rule.

[439] I do not intend to indulge in this question further. I am only raising this issue to illustrate the problematic nature of the present argument.

IV.2 Arguments for the infinite divisibility of matter

Now, I will turn to the opposing party, and see what arguments Aristotle furnishes for infinite divisibility. In deference to the reasons mentioned in the beginning of the chapter, and similarly as in the case of the Atomists, my analysis of the Aristotelian passages will also focus on the physical divisibility of matter. Although, when relating the argument of Democritus (*De Generatione et Corruptione,* 316a15-17a1), Aristotle describes a reasoning which can be interpreted as relating to physical divisibility (see: page 147), his arguments for infinite divisibility seem to work only if one goes further than simple physical division into the realm of parts which are mentally separable from each other (but not physically). In other words, these arguments make no or little sense if applied to physical divisibility.[440] Furthermore, as we shall see, some of the following passages, instead of concerning material objects, relate to geometrical extensions (or even size-less entities, like points). Since my subject matter is the physical divisibility of material objects, in the following, instead of furnishing a detailed analysis of the pertaining passages, I confine myself to the demonstration of the above mentioned.

There are two passages where Aristotle attempts to refute the existence of indivisibles. There is a brief argument in *De Caelo* (303a20-4; 306a26-b1), and there is a relatively long interconnected discussion in book VI of *Physics*, which is partly aimed at proving the infinite divisibility of all kinds of spatial extensions. Firstly, I will consider the argument of *De Caelo*. Embedded in a discussion on the early Atomists (303a3-303b3), Aristotle formulates the following criticism against the view that matter is reducible to primary indivisible particles:

"Besides, a view which asserts atomic bodies must needs come into conflict with the mathematical sciences, in addition to invalidating many common opinions and apparent data of sense perception. But of these things we have already spoken in our discussion of time and movement."[441]

[440] Several scholars have observed this general feature of Aristotle's arguments against atomic magnitudes. For instance, see: Furley, 1967, pg 86-90; Miller, 1982, pg 90; Sinnige, 1968, pg 145-6.
[441] 303a20-4; See also: 306a26-30.

According to the passage, the proposition that there are “atomic bodies” (ἄτομα σώματα) is incongruous with: 1, mathematical knowledge (μαθηματική ἐπιστήμη); 2, common opinion (ἐνδόξα); 3, sense perception (φαινομένα κατὰ τὴν αἴσθησιν). I agree with Furley that (1,) can only make sense, in case the bodies in question are not only physically, but theoretically indivisible as well.[442] Before furnishing an explanation, we must look into the reason underlying (1,). In his commentary, Simplicius argues that the principles of mathematics require all geometrical “magnitudes” (μέγεθος) to be divisible *ad infinitum*, but the rejection of infinite divisibility with respect to material objects abolishes infinite divisibility in general.[443] Therefore, its denial in the physical world will entail its denial in mathematics as well. From this, it follows that lines, planes and three-dimensional extensions will all consist of indivisible units.

This reasoning works only in the case of mental division. After all, the belief in physically indissoluble particles does not preclude the possibility of dividing these particles further in the mind. Neither does it prevent us from considering infinitely divisible geometrical extensions in abstraction from physical matter. In the case of theoretical division, for someone like Aristotle, who upheld the view that geometrical extensions must be derived from real life objects, the supposition of atoms with mentally indistinguishable parts could indeed entail that all forms of geometrical objects, by virtue of being ontologically dependent on their material counterparts, are theoretically indivisible as well.[444] Based on these considerations, (1,) can only make sense, if the atoms in question are regarded as theoretically indivisible.

Concerning (2,) and (3,), the passage does not explain why a theory advocating the existence of indivisibles would contradict either sense perception or common

[442] Furley, 1967, pg 87-8.

[443] Simplicius, *On the Heavens*, 612, 9-14; In the *Physics* (chapter 1 of book VI), Aristotle argues for the notion that all extensions (not just three-dimensional ones) must be infinitely divisible, and “continuous” (συνεχής).

[444] In Aristotle’s theory, geometrical objects are constructed through the abstraction of the properties of real-life bodies. For instance, if I want to construct a particular surface, I abstract it from a suitable material object in my mind. This view entails that those kinds of extensions which are not present in the Aristotelian Cosmos (such as infinite surfaces, or lines), are not even conceivable in the mind (*Metaphysics*, 1078a21-31; *Physics*, 193b31-5). For an extensive discussion on this question, see: Mueller, I, ’Aristotle on Geometrical Objects’, *Archiv für Geschichte der Philosophie*, vol.52, issue 2, pg 156-71 (1970).

opinion. Simplicius' brief allusion that "sense perception is not possible, if our bodies are not unified (possibly referring to the void gaps between the atoms)" adds little force to the argument. After all, the Atomists could reply that all forms of sense perception are the result of the movement and interaction of particular atoms within the body, a theory which does not require that the physical body must constitute a unified mass.[445] All in all, due to the lack of detail, it is not possible to evaluate (2,) and (3,). With respect to (1,), as we have seen, it exclusively relates to theoretical divisibility, and the question whether the atoms were both mentally and physically indivisible, or just the latter, cannot be decided. Based on these considerations, I conclude that the passage of *De Caelo* (303a20-4) is not directed against the physical indivisibility of matter; therefore, I will not analyse it further.

As I have laid down above, the situation is similar with respect to the discussion of the *Physics* as well. Let us look at some of the underlying reasons. As previously, I am analysing the argument in order to demonstrate that it works exclusively with theoretical divisibility. In the beginning of book VI (231a21-b18), Aristotle furnishes an argument for the notion that no extensions (be it a line, a surface, or a three-dimensional object) can consist of indivisible units. Taking the underlying assumption that all extensions are "continuous" (συνεχές) as a basis, Aristotle endeavours to demonstrate that nothing συνεχές can consist of indivisibles. The underlying reason is that two things are continuous in so far as their extremities are "together" (ἅμα), occupying the same spatial location.[446] However, since indivisible units lack parts, their limits cannot be distinguished (from their other "non-existent" parts). Consequently, their extremities can occupy the same place (the requirement for constituting a continuum) only if both parts are together as a whole, and coincide entirely. However, in this case they cannot form a continuum, since the latter must be divisible into parts, which are continuous, yet spatially distinct (231b4-6). Hence, the argument concludes that all extensions, by dint of being continuous, must be

.[445] For the Atomists' account of sense perception, see: Bailey, 1928, pg 101-6, 162-75, 384-437; Furley, 1987, pg 131-5; Rist, 1972, pg 80-8.

[446] This follows from the definition of συνεχές. For the definitions of "being continuous", "be in succession" (ἐφεξῆς), "in contact" (ἅπτεσται), "being consecutive" (ἐχόμενος), and "togetherness" (ἅμα), see: *Physics*, chapter 3 of book V.

divisible into parts which are themselves further divisible. In other words, extensions in general must be infinitely divisible (231b15-8).

Like the one presented in *De Caelo* (303a20-4; 306a26-b1), this argument can only make sense, if the parts in question are regarded as both physically and theoretically indivisible (the latter always entails the former). After all, the reasoning pivots on the statement that indivisibles do not have distinguishable extremities, a statement which seems to follow only from theoretical indivisibility. In contrast, as Furley observes, if the units, constituting the continuum, were just physically uncuttable, it would still be possible to regard their limits in separation from their other parts.[447] Furthermore, being physically indivisible does not mean that these units cannot be spatially extended.

In fact, it seems that the argument is not even directed against spatially extended indivisibles. Instead, Aristotle attacks the notion that lines (or other forms of extensions) consist of indivisible points, which are clearly regarded as size-less. From this fact, Miller deduces that the argument in question is not even directed against Atomism.[448] Although he asserts it with certainty, I would only go as far as to maintain the possibility that Aristotle does not attack the Atomists in this particular passage. On the positive side, I accept Miller's statement that, when relating the chief argument for the existence of atoms in the *De Generatione et Corruptione*, Aristotle seems to attribute spatial magnitude to the atoms.[449] In contrast, in the *Physics* (231a21-b18), Aristotle uses the "point" (στιγμή) as an example for the kind of indivisible under criticism, and points lack magnitude. This fact renders less likely that the primary indivisibles of the Atomists are being considered here, since Aristotle does not equate the latter with points.[450] The passage's lack of explicit reference to the Atomists further strengthens Miller's case.

[447] Furley, 1967, pg 89.
[448] Miller, 1982, pg 101-2.
[449] For more explanation, see: Miller, 1982.
[450] For instance, the Atomists' argument reported by Aristotle (*De Generatione et Corruptione,* 316a15-17a1) specifically introduces the atoms in order to obviate the possibility of material objects being reduced to "nothings" (or points) via the process of division. Consequently, in the context of this particular argument, the atoms cannot be identical to points.

On the negative side, there are several sources (both ancient and modern) which understand the argument as a criticism of the Atomists' views as well.[451] Furthermore, unlike Miller, Furley only states that the argument is directed against the view that extensions consist of theoretically indivisible units. However, since Furley regards the atoms (of the Atomists) as theoretically indivisible as well, he does not reject the idea that this particular argument is intended by Aristotle to refute the Atomist theory.[452] The fact that the majority of the relevant Aristotelian passages do not demonstrate a clear awareness of the difference between theoretical and physical indivisibility leaves open the possibility that, in this particular argument, Aristotle happens to adduce qualities exclusive to theoretical indivisibles (lack of mentally distinguishable parts, lack of magnitude) without being conscious of the fact that this confines his argument to theoretical divisibility. In other words, it is possible that, here, Aristotle intends to argue against indivisibility in general, while (unwittingly) adducing reasons, which work only if the indivisibility is regarded as theoretical. Consequently, we cannot say for certain that Aristotle limits his argument to theoretical divisibility, a fact which would exclude the Atomists as potential targets.

All in all, there are reasons both for and against Miller's idea that the argument of the *Physics* (231a21-b18) is **not** directed against the Atomists, and to decide this question would require a more extensive discussion, which exceeds the scope of my work. The only statement which can be derived from the above considerations with reasonable certainty is that the argument is effective only against indivisibles, which lack mentally distinguishable parts, and cannot be used as a refutation of physically unsplittable atoms.

After demonstrating that all forms of extensions are continuous and infinitely divisible, the *Physics* continues with a series of arguments in favour of the notion that magnitude, movement and time are all subject to the same division. In other words,

[451] For instance, Simplicius' commentary on the passage contains references to Democritus and Leucippus (*On Aristotle Physics*, 925, 1-929, 19). Bostock (see: Waterfield, 1996) also regards the argument as being intended against the Atomists (see: notes on the relevant passage, and Introduction, pg li-v).

[452] Besides maintaining that it solely concerns theoretically indivisible units, Sorabji also takes the argument to be directed against the Atomists (1983, pg 365-9).

either all are composed of (theoretically) indivisible elements, or none.[453] Aristotle contends for the latter alternative, maintaining that magnitude, motion, and time are all infinitely divisible. All of these arguments concern theoretical division, a fact which I will demonstrate with respect to the first one, presented at 231b21-32a17.[454]

Here, Aristotle argues that if A, B and C are indivisible magnitudes, motion through them will consists of the corresponding indivisible units as well. Since, for Aristotle, the later possibility entails various absurdities neither motion nor magnitude (space or distance corresponding to the movement) can consist of indivisibles. In order to illustrate this, Aristotle distinguishes the state when the object "is moving" over A (has entered into it, but still has not completely left A) from the state when it "has already moved" across A. Let us denote these states with "N" and "M" respectively. After demonstrating that an object cannot be in both states simultaneously (231b28-a1), Aristotle proceeds to show that, when a body "X" moves over a distance, at first, it is always in state N, then in M. However, this is not realizable unless the given distance is divisible (32a1-4). In case it is not divisible (the premise of the argument), motion turns into a series of M states (32a6-9). In other words, instead of being in motion through ABC, X only "appears" in A (has moved to it), then in B, then in C. Although it is not explicitly stated, for the sake of simplicity, let us assume that A, B, C, and X correspond in size.[455]

Why does Aristotle argue in this way? Why is the indivisibility of distance incongruous with "being in motion"? A viable explanation is that N is viewed as a continuous process, in which X gradually proceeds from A to B. This entails the following: 1, during the movement, X is partly in A and partly in B; 2, it holds true for both A and B, that some parts of them are occupied, whereas others are empty.[456] However, (2,) is not possible, if either A or B is theoretically indivisible. After all, the occupied parts (of A and B) must be distinguishable from the vacant sections at least theoretically.

[453] 231b18-20.
[454] For a more extensive analysis of these arguments, see: Furley, 1967, pg 114-21; Miller, 1982, pg 102-9.
[455] This stipulation does not restrict the argument in any way.
[456] We stipulated that A and X correspond in size. Therefore, when a part of X leaves A, a corresponding portion of A must become empty.

Therefore, A and B must be divisible in the mind. In fact, by constructing A and B arbitrarily small, this entails the infinite divisibility of distance (or space) as well.

Notwithstanding, Aristotle's reasoning only works against the theoretical indivisibility of space, whereas we are concerned with the physical indivisibility of matter. After all, the physical indivisibility of the object which traverses A neither prevents A from being in a part filled and part empty state nor entails A's theoretical indivisibility. In other words, it is perfectly conceivable that a physically unsplittable body (be it an atom) is "being in motion" from A to B, while violating neither (1,) nor (2,). Consequently, this reasoning, and as a result, the whole argument presented at 231b21-32a17 cannot be used to refute the physical indivisibility of matter. As I have mentioned, in book VI, Aristotle furnishes additional arguments to prove that both magnitude, time, and motion are divisible *ad infinitum*. However, since the fact that they all concern theoretical divisibility can be demonstrated in the similar manner as I did above, I will not proceed to consider each of them severally.

The same can be said about two further passages (234b10-21; 240b8-31), where Aristotle argues that something without parts cannot move, or undergo any forms of change. Like the ones considered previously, this argument works only against entities lacking theoretically distinguishable parts. By and large, Aristotle rejects the possibility of change with respect to entities without parts on the following grounds: when X changes (or moves) from A to B, some parts of it must remain in A (those which are yet to change), whereas some must already be in B (those which are already changed). However, this is impossible unless X consists of distinguishable parts.[457] Obviously, in order to obviate Aristotle's criticism, it is sufficient to ascribe theoretically discernable parts to X, which does not preclude the physical indivisibility of X. Consequently, this argument cannot be used to refute the physical indivisibility of matter either.

After considering the various arguments of Aristotle in which he attempts to refute the existence of indivisibles, I concluded that, in all instances, Aristotle's reasoning works only against theoretical indivisibles. As we have seen, there is only one passage

[457] Incidentally, albeit based on different reasons, the Atomists would agree with Aristotle in so far as their atoms indeed cannot undergo any kinds of change except locomotion.

in *De Generatione et Corruptione* (317a2-12) which can be interpreted as considering physical divisibility.[458] However, this is more of a refutation of the Atomists' argument (for the existence of indivisible primary particles) than an actual argument for the infinite physical divisibility of matter. Therefore, I conclude that there is no extant passage, where Aristotle directly attacks the idea that matter consists of physically indivisible particles.

IV.3 Conclusion

In the current chapter, I have examined arguments either for or against the idea that matter consists of primary indivisible particles (the atoms), which serve as a lower limit to all kinds of physical division. In doing so, I confined my analysis to arguments which can be understood as concerning physical divisibility (not theoretical). With respect to the Atomists, I have identified several such arguments which were intended to prove the physical indivisibility of matter. Overall, my analysis has revealed that neither the arguments of the early Atomists nor those of Epicurus and Lucretius manage to fulfil their intended purpose.

The early Atomists' chief objection to infinite divisibility (or "divisibility everywhere" to use Aristotle's expression) is that it would entail the absurd consequence of material objects consisting of mere "nothings". However, by highlighting the distinction between two senses of πάντῃ διαιρετός, Aristotle successfully disproves the argument (see: pages 153-5). As Aristotle correctly observes, unless the object is divided simultaneously at every point, we can avoid the absurd conclusion of the Atomists' argument. The two pertaining arguments of Epicurus and Lucretius are no more convincing. In brief, the first one argues that the property of infinite divisibility would render composite bodies too weak to survive the process of dissolution, which, in turn, would inevitably destroy them.[459] However, as we have shown, neither we nor Aristotle are compelled to accept the Atomists' theory concerning generation and

[458] For my analysis of the passage, see: pg 153-4.
[459] Diog. L., x. 41 and 56; Lucretius, *De Rerum Natura*, 1.538-64; For my analysis, see: pg 156-60.

destruction, without which the argument fails. The underlying reasoning (and my refutation) of the remaining argument of Epicurus (Diog. L., x.57) is rather complex, and cannot be effectively recapitulated in a few words. Nonetheless, as I have demonstrated (see: pages 163-4), it is no more convincing than the one summarized above. All in all, the Atomists fail to refute the idea that matter can be physically divided ad infinitum.

Considering the opposite view, my analysis revealed that Aristotle does not furnish any arguments by which the existence of physically indivisible particles can be unequivocally disproved. Despite the fact that he presents several arguments against indivisibles, none of these have any efficacy unless we regard the indivisibility as both physical and theoretical. I have demonstrated that Aristotle's arguments are ineffective against particles which are physically uncuttable, but theoretically divisible. For instance, the one presented in *De Caelo* (303a20-4; 306a26-b1) states that the belief in atoms contradicts the mathematical principle that all extensions should be divisible ad infinitum. However, the belief in physically indissoluble atoms, which are theoretically divisible, is not incongruous with the infinite divisibility of geometrical extensions.

I have made similar observations with respect to the relevant arguments of the *Physics*. In the beginning of book VI (231a21-b18), Aristotle contends that no extensions can be comprised of indivisible elements. An essential link in his reasoning depends on the idea that, by virtue of lacking distinguishable extremities, indivisibles cannot constitute a continuous extension. However, as I have demonstrated (see: page 168), in the case of physical indivisibles, by dint of containing mentally distinguishable parts, their limits, by which they might form a continuum, can be ascertained as well. The relevant arguments contained in the remainder of book VI also work only against theoretical indivisibles. In addition, in the argument against the notion that magnitude, motion, and time consist of indivisible units Aristotle does not even consider the divisibility of material objects. Rather, his reasoning seems to be directed against the notion that space, through which an object moves, consists of theoretically indivisible units.

All in all, neither the Atomists nor Aristotle manage to prove their case. As a result, based on their arguments, the question whether there is a limit to the physical division of matter or not remains unresolved. This fact bears some relevance to our discussion on void, which was considered in the previous chapter. There, the question whether empty space is required for motion to occur or not proved to be dependent upon the divisibility of matter. To recapitulate, the Atomists attempted to prove the existence of void by stating that its existence is necessary for locomotion.[460] Aristotle refuted their argument by demonstrating that motion is possible without void, since objects can "yield" to each other. However, as I have shown, Aristotle's counter-argument works only if the matter constituting these objects is infinitely divisible.[461] In other words, the success of Aristotle's refutation depends on the divisibility of matter. Since neither the Atomists nor Aristotle manage to prove the veracity of their own view with respect to the divisibility of matter, the result of our analysis (found in chapter III), remains unaltered. In other words, the question whether empty space is necessary for locomotion or not cannot be decided.

[460] This is the so-called "from motion to void" argument, which is designed to deduce the existence of empty space from the phenomenon of motion. For more details, see: chapter III.3.
[461] Otherwise, the process, in which one object "yields" to another, inevitably leads to the generation of void interstices between the two bodies.

Chapter V

Summary

In my work, I have considered three questions, each of which relates to a particular property of our universe. In doing so, I limited my scope to Aristotle and the Atomists and analyzed their pertaining arguments. I have talked in detail about the reasons for doing so in the Introduction. Here, let it suffice that there was some form of debate between the two sides, where each side showed some degree of awareness of the other's opposite standpoint (and pertaining arguments). This fact provided an ideal basis for a detailed comparison of their opposing arguments, based on which the structure of the debate can be reconstructed as follows: the early Atomists furnished an argument, which is often (albeit not always) also preserved by Aristotle. In either case, as has been seen in my analysis, Aristotle was undoubtedly aware of the Atomists' standpoint, and attempted to refute it.[462] When we arrive at the arguments of Epicurus and Lucretius, the picture becomes a bit more complex. On the one hand, we saw instances where Epicurus was clearly aware of Aristotle's objections and reacted to them. For instance, Aristotle complained that there can be no universal "up" and "down" within the infinite, and the Atomists failed to distinguish the natural motion of atoms from their other movements.[463] In reply, Epicurus demonstrated how these directions can be ascertained in an unlimited universe. In addition, to avoid Aristotle's second objection, Epicurus modified the theory of his predecessors, and stated that all atoms naturally move downwards. On the other hand, there is also some evidence pointing in the opposite direction. For instance, when constructing one of his arguments for infinite space, Epicurus either was unaware of, or

[462] This does not mean that Aristotle argued exclusively against the Atomists. However, we have seen several arguments (of Democritus and Leucippus) which were related by Aristotle, who regularly appended his own refutation of the Atomists' argument. For instance, in his *Physics* (231b4-22), Aristotle described several arguments (including that of the Atomists) for the existence of empty space. Then, he went on to provide counter-arguments for each (214a22-b11).

[463] See: chapter II, points A-D on page 53.

disregarded, Aristotle's earlier distinction between "limitedness" and "being in contact".[464] In addition, both Epicurus and Lucretius frequently adduced arguments which were similar to those of the early Atomists, irrespective of the fact that Aristotle had already dismissed these arguments. A good example for this is the so called "from motion to void" argument which was retained by the Epicureans, despite the fact that Aristotle had rejected it previously.[465]

Although there are many aspects of the above debate, my main objective was to investigate its outcome. Therefore, when considering the arguments, my principal aim was to ascertain their validity. In other words, tackling each question in separation, I endeavored to decide which side managed to prove their case conclusively or achieved more success in this respect. My investigation yielded the following results. In general, neither side achieved a complete victory. With respect to all three questions, neither Aristotle nor the Atomists managed to prove their case conclusively. That said, concerning the first two questions, the Atomists proved to be more successful than Aristotle. Let us recapitulate the reasons for the Atomists' partial success, taking each question separately.

When considering the dimensions of our universe, we encountered the so called "Archytas" argument, which I will not describe here.[466] Let it suffice that this argument, which was most likely used by the Atomists as well, falls close to proving the infiniteness of space, if the latter is regarded as conventional (not "curved" as modern physics maintains). Namely, supposing space to be conventional just as the ancients did, it feels more natural and in accordance with ordinary experience to accept Archytas' reasoning for the infiniteness of space than to reject it. What's more, none of the counter-arguments which I have considered manages to disprove Archytas' argument. That said, due to certain reasons,[467] this argument still cannot be regarded as a "definite proof" for the infiniteness of our universe. Nonetheless,

[464] See: chapter II, pg 28.
[465] See: chapter III, pg 105.
[466] See: chapter II, pg 31-5. For a more detailed summary of the results of my analysis, consult the conclusions of each chapter.
[467] For these, consult my analysis of the argument.

by virtue of it, the Atomists achieve more success in proving their case than Aristotle, whose arguments for the finiteness of space turned out to be entirely inconclusive.

With respect to the existence of empty space, at first, I endeavoured to determine the exact meaning of the Atomists' concept of void with the following result. Although not with definite certainty, the available evidence strongly suggests that both the early Atomists and the Epicureans regarded void as separately existing, three-dimensional space which can be either filled or unoccupied.[468] Incidentally, Aristotle looked at the Atomists' concept in the same way, a fact which further facilitated my analysis. Returning to the results of my comparison of the arguments, Epicurus and Lucretius proved to be (at least) partially successful in their attempt to prove the reality of τὸ κενὸν.[469] In brief, they constructed an argument based on empirical evidence, which states that our senses attest to the reality of the following: 1, bodies exist (in a material sense); 2, bodies move. According to the argument, both (1,) and (2,) require the existence of receptive empty space (the void of the Atomists).

Following both the Atomists and Aristotle, if we accept the basic premise that our senses indeed attest to (1,) and (2,), the Epicurean argument holds in connexion with (1,).[470] For, as we have seen, (1,) demands that there must be something where objects can exist in a material sense. In addition, I concluded that this something (the place of the object) must exist independently from its occupant. As it turned out, the only suitable candidate capable of fulfilling these requisites, was a separately existing, three-dimensional spatial entity, which I referred to as the "occupied parts of void".[471] In other words, the Epicurean argument manages to prove those parts of void which are filled by objects.

With respect to the empty parts of space, as we have seen, (1,) does not require their postulation, and we need to rely on (2,) for proof of their existence. In essence, (2,)

[468] For the entire discussion, see: beginning of chapter III.
[469] See: chapter III, pg 105-12.
[470] We have seen that both Aristotle and the Epicureans regarded the empirical evidence as more or less trustworthy. In this respect, the early Atomists were undoubtedly more sceptical. Nonetheless, as I have demonstrated (see: chapter III, pg 98-102), we have no reason to believe they questioned the reality of either (1,) or (2,).
[471] The only alternative option was to accept the *Physics'* two-dimensional, surrounding notion of place. However, I rejected this notion in view of the numerous problems it entails.

is similar to the so-called "from motion to void" argument, recounted by Aristotle (*Physics*, 213b4-14). Although the passage does not mention them by name, for reasons described in my analysis, I ascribed this argument to the early Atomists. In brief, it attempts to prove the existence of empty space from the phenomenon of movement, which is evidenced by our senses. My evaluation of the argument yielded ambivalent results.[472] In a sense, Aristotle managed to disprove it by offering an alternative explanation for motion which did not require void space. However, as we have seen, even his theory (that objects can "give way to each other") led to the generation of empty interstices between the moving bodies, if matter was not infinitely divisible (in the physical sense). Consequently, I concluded that Aristotle's refutation of (2,) worked only if matter is divisible ad infinitum. In the opposite case, the "from motion to void" argument turns out to be valid. All in all, the outcome of the debate concerning the empty parts of space depends on the divisibility of matter. In other words, if the Atomists are correct in assigning a lower limit to the physical division of matter, the existence of the empty parts of space is also proven. Conversely, if Aristotle rightly rejects the existence of such a limit to division, his refutation of the above "from motion to void argument" might well be accepted as well.

In part to decide the above question, in chapter IV, I turned to investigate the arguments concerning the physical divisibility of matter. In this respect, my investigation was fruitless, since I concluded that neither Aristotle nor the Atomists managed to prove their case with respect to the divisibility of material objects. The Atomists did not furnish any conclusive proof for the existence of physically indivisible atoms. In other words, unlike in the case of the questions considered in the other chapters, they were not even partially successful. Looking at those of Aristotle's arguments which argue for infinite divisibility, I found that none of them relate to my subject matter, the physical divisibility of matter. Therefore, I altered my approach in the following manner: instead of ascertaining the validity of these arguments, I focused on demonstrating that, in each case, Aristotle seems to argue

[472] See: chapter III, pg 103-5.

against entities which are not just physically, but theoretically indivisible as well.[473] This fact entails that his arguments are ineffective against particles, which are physically uncuttable, but theoretically divisible. In addition, I found that several of these arguments do not relate to physical particles, but concern geometrical extensions in general, or even size-less entities, such as points.[474] All in all, since Aristotle's arguments are ineffective against physically indivisibility, they cannot refute the existence of physically unsplittable atoms whose relation to theoretical divisibility, as has been mentioned, is highly controversial.

To recapitulate, with respect to all three questions, Aristotle did not furnish any convincing arguments. In contrast, although not proving their case entirely, the Atomists were comparatively successful in arguing for the infiniteness of space and the existence of void. In my opinion, the reason why the Atomists fared better than Aristotle lies in the fact that, in the above two questions, their standpoint was more defensible from the beginning. What I mean is that their standpoint is more in accord with common sense, whereas the opposite view seems to be counter-intuitive. After all, as long as one regards space as conventional (not the "curved" space of modern physics), it feels more natural to assume that the universe is endless. As far as I am concerned, the opposite view that the universe is a sphere and there is an invisible wall or some unidentifiable "nothingness" at the edge defies experience and seems excessively counter-intuitive. Albeit less intimately connected, something similar can be derived from my discussion on void. Here, we have seen how Aristotle's unique view on "place" lead him to reject the existence of void. However, this two-dimensional surrounding interpretation of τόπος proved to be highly problematic. In addition, the fact that it garnered little or no popularity even in ancient times hints at its counter-intuitive nature. As we have seen, in contrast to the two-dimensional interpretation, regarding place as three-dimensional extension which can accommodate objects yet exists independently from them seems to be the more natural and acceptable solution.[475] This "more natural" concept of place enabled

[473] For the distinction between physical and theoretical divisibility, see: beginning of chapter IV.
[474] These are the arguments located in book VI of *Physics*.
[475] For my discussion of Aristotle's notion of place, see: chapter III, pg 106-11. My discussion also contains the argument for the "independent" nature of place.

Epicurus to construct an argument which successfully proved the existence of the "occupied parts" of void. However, for reasons which I have already described, the existence of the empty parts remained unproven.

The above concludes my summary of the outcome of the debate between Aristotle and the Atomists concerning three related questions: the extension of space, the existence of void, and the (physical) divisibility of matter. In the remainder, I will mention some of the more common problems, which I have encountered during my analysis, and which played an instrumental role in rendering the vast majority of the discussed arguments inconclusive. By and large, these problems can be classified into three categories, each of which I will discuss in succession. Although there are common features shared by problems from different categories, each of them can be assigned reasonably straightforwardly into its own place. From the three categories, I have already distinguished two as part of my introduction to Aristotle's arguments against the infiniteness of space.[476] The reason why I originally mentioned these categories first in connexion with Aristotle is that such problems feature much more frequently in Aristotle than in the Atomists. With respect to both categories, the problem originates from the presence of certain notions, which are not necessarily valid, and whose proofs are completely missing from the argument. All the same, they are presupposed (regarded as valid, or even self-evident). These notions are expressed either explicitly or implicitly. In either case, the conclusion of the argument is based on them (or at least, the conclusion does not hold without them being assumed). The difference between the two types lies in the question whether these notions are sufficiently argued for elsewhere or not.

The first category constitutes those notions or propositions which I referred to as "first assumptions" in deference to their similarity to Aristotelian axioms. These "first assumptions" are not argued for anywhere within the extant corpus; therefore, their validity appears to be taken as self-evident.[477] In contrast, the second category consists of notions, for which there are reasonably extensive arguments found in

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[476] Chapter II, pg 37-9.

[477] In the present context, I refer to a proposition as "self-evident", if its validity is assumed by the argument despite the fact that it is not proven.

other passages, often presented in the same work, and in close proximity to the original argument which relies on them. Examples for the first category are the following:

- Aristotle: there are simple motions, and their number is two; every simple body moves naturally to its proper place; only bodies can be three-dimensionally extended; absolute directions (especially, the pair of upwards and downwards) exist in our universe.[478]
- Atomists: generation and destruction occur through the association and dissociation of atoms.

The following are examples for the second category:

- Aristotle: certain notions corresponding to Aristotle's elemental theory (for instance, the existence of a "fifth element" (αἰθήρ)); the concept of "place" as defined by the *Physics*;[479]
- Atomists: there are an unlimited number of atoms in our universe.[480]

As I have said, neither we nor the ancients are compelled to accept the validity of the above notions as long as their proof is not presented by an argument. With respect to first assumptions, since they are neither adequately proven nor self-evident, a conclusion deriving from them cannot be accepted. What is more, some of them (for instance, the dual proposition that "there are simple bodies, and each moves to its own place") are clearly wrong. Concerning the members of the second category, since they are argued for elsewhere, it might be possible to ascertain their truth-value by looking at the appropriate passages. However, seeing that this endeavour often entails the inclusion of otherwise irrelevant material, aside from one or two exceptions, I did not proceed to investigate the validity of such notions. Instead, if a particular argument did not hold without such a proposition, I dismissed it on the

[478] It must be noted that this list is limited to those notions (or propositions) which I encountered during my analysis, and which were presupposed in such a way as to render the arguments in question ineffective. There might well be more such notions present in arguments which I have not considered. For more detail concerning the problems caused by these propositions, consult the relevant parts of my analysis.
[479] As we have seen, even Aristotle's rejection of place as an independent three-dimensional extension was sufficient to preclude the existence of void (chapter III, pg 115-6).
[480] See: chapter II, pg 28-31.

following grounds: 1, the proposition in question is not self-evident, and its proof is missing from the argument; 2, due to (1,), the conclusion cannot be accepted without qualification, and ascertaining its validity would require a detailed analysis of additional arguments, in which the proposition itself was originally argued for.[481] As I have said, this was the only feasible way to treat these arguments, since the lack of space precludes the possibility of analysing the truth-value of each and every occurent proposition.

Lastly, there is a third category which consists of certain flawed physical laws or proportions. This category relates exclusively to Aristotle's arguments, in which he mistakenly presumes various flawed laws (especially, ones concerning movement), and based his conclusions on them. For instance, some of Aristotle's arguments against void are based on his theory of "forced movement" or certain proportions between speed of fall and the density of the corresponding medium. Elsewhere, Aristotle relies on certain proportions which are based on his view that "a heavier object falls downwards faster than a lighter one".[482] As we have seen, none of the relevant arguments hold if these kinetic laws are false. Since they are indeed wrong, the arguments which rely on them are invalid as well.

The above constitutes the compilation of the more common problems, which I have encountered during my analysis, and which played a significant role in rendering the vast majority of the discussed arguments inconclusive. Obviously, this is not an exhaustive compilation of all the reasons which I adduced during my refutations of the arguments. Each argument has its own logical structure and set of premises. Therefore, in a sense, its refutation is also unique to the argument. Hence, if the reader is interested in the way I refuted a particular argument, they are encouraged to consult with the relevant part of my analysis contained in chapters II-IV.

[481] Obviously, the falsity of some of these notions (for instance, the existence of αἰθήρ) is apparent even without looking at the passage where they are argued for.
[482] See: chapter II, pg 64-5.

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